SOMATIC DEVELOPMENT OF ADOLESCENT BOYS

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Somatic Development
OF ADOLESCENT BOYS

A STUDY OF THE GROWTH OF BOYS DURING THE SECOND DECADE OF LIFE

by

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and

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FOREWORD

THE publication of this book brings to fruition an idea and a long-sustained endeavor of Dr. Stolz and his associates. Its appearance will be welcomed by all those who are interested in the development of adolescent boys, and especially by those who have seen some of the earlier tentative findings from this study.

In this volume are presented the basic data from a longitudinal study with the interpretation that shows, perhaps more clearly than any previous study, the underlying dynamics of the growth process in the second decade of life.

The literature on growth is replete with measurements of various kinds taken at different ages. For the most part these measurements are cross-sectional—made at one given time on a group of subjects and as such largely static, especially when treated in static terms (or age norms).

It is the peculiar, if not unique, significance of this study that it has sought for an understanding of process, of the dynamics of growth as revealed by a variety of simultaneous measurements *on the same identified individuals,* repeated at intervals over a period of years and then interpreted to reveal the underlying processes that have produced these *different but equivalent* products, in these *identified* individuals.

This study is also unique in the use of serial photographs which have made it possible to discover what measurements alone cannot reveal—the successive *transformations* whereby the juvenile organism is transformed into the adolescent and then into the young adult by a series of changes and alterations that must not only be visualized, but also individualized, if their dynamic significance is to be discovered. In the usual statistical tabulation and search for central tendencies and various norms, these transformations and patterns of growth, turning points, and asynchronous changes tend to cancel out or merge into each other and so rob the data of their potentialities for revealing the dynamics of growth in individuals.

The authors are especially to be commended for their promising effort at revealing the processes of growth and maturation in the male genitalia, of which there has been little understanding heretofore. The ingenious use of serial photographs has made possible careful observations of the changing

size of the genitals and thereby revealed the sequential patterns in their maturation.

Because Dr. Stolz and his associates have courageously explored for new methods of analyzing and interpreting their data in this search for a more holistic conception and for an understanding of the different patterns of achieving maturation, this study marks a definite turning point in the field of child development. It shows how the clinical approach can be utilized in longitudinal studies. Some who prefer the now classical methods of anthropometry and the customary static presentations may object. But all those who are concerned with the understanding of adolescent development will be grateful to Dr. Stolz for his imagination, his courage, and his perseverance in bringing this study to completion and publication.

The various chapters will provide much needed understanding of the rhythms, timing, and cycles of growth, the normal deviations, even seeming regressions, and what has often been regarded as abnormal, like the "early adolescent fat period."

We are becoming aware that there are various paths to adulthood and that individuals with much the same dimensions may arrive at adult status by different patterns and rates of growth, some growing fast, others slowly, each traveling through the sequences of development at his own rate to the size, shape, and weight that are idiomatically his own. In biological and psychological studies we are beginning to realize the importance of recognizing the equivalents that are often ignored because the absolute quantitative differences obscure their relative significance and the similarities in different subjects.

Readers of this volume may find it helpful to read first Chapter XVII, "General Summary and Discussion," in order to grasp the major conceptions and findings before they study the preceding chapters. Some readers, especially those who are concerned with teaching and guidance of adolescent boys, will find Chapter XVIII especially illuminating, with the detailed description of how Ben grew and what difficulties and problems he encountered.

This account of Ben's experiences in growing up may serve to modify the widely accepted view that there are no new problems in adolescence: the individual is primarily engaged in living over his early childhood problems. This view has ignored the importance of the growing, developing organism, with all the confusion and conflicts the changing body may engender and the often crucial problem of revision of the image of the self as the child's body is transformed into an adult.

This volume will be of value to all those engaged in child development research, pediatrics, education, physical training, and counseling and guid-

ance. It will, also, it is hoped, be taken into account by the military authorities when they undertake to train adolescent boys. For physicians dealing with the practical clinical problems related to growth Dr. Stolz suggests that Chapter XIV on genital development, Chapter XV on the early adolescent fat period, Chapter XVI on the rhythm of growth, and the general summary in Chapter XVII may be particularly useful.

As the authors have pointed out in Chapter I, we have long accepted the belief in the great importance of protecting, educating, and guiding our children. To carry on this purpose of conserving our human resources, we need ever more understanding of the processes of growth, development, maturation, and aging so that we can more effectively protect and evoke the potentialities of the unique individual throughout the life career. *Somatic Development of Adolescent Boys* is a major contribution to that endeavor.

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THE study of somatic development of boys which is discussed in this book was one part of the California Adolescent Study begun in January, 1932. This study was under the joint auspices of the Institute of Child Welfare of the University of California in Berkeley, California, and the Public Schools of Oakland, California. The study was initiated and planned by the staff of the Institute under the direction of Herbert R. Stolz, Director of the Institute from 1925 to 1934, with the collaboration of Lawrence K. Frank, at that time on the staff of the Laura Spelman Rockefeller Memorial Fund. The study was financed by the Laura Spelman Rockefeller Memorial Fund and the General Education Board with contributions from the Oakland Public Schools.

The data for the study of somatic development of boys were collected by Herbert R. Stolz with the assistance of Frank Sawyer, M.D., and Nathan Shock, Ph.D. The roentgenographic data were collected and appraised by Dr. Nancy Bayley. We are also indebted to Dr. Bayley for data collected by her on certain of the supplementary cases which were part of another longitudinal study under the auspices of the Institute.

The data on social development used in the analysis of the case presented in Chapter XVIII were collected by a number of workers including Judith Chaffey, Dr. Caroline Tryon, the late Dr. Jaffry Cameron, Dr. Mary Cover Jones, Mrs. Frances Burks Newman, and the late Howard Wells. We wish to acknowledge our indebtedness to all these research workers who did the arduous work day after day during a seven year period.

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The publication of this study was ultimately achieved through a subsidy from the General Education Board to the University of California and through the personal interest of Mr. W. Holt Seale, Manager and Editor in Chief of the Medical-Public Health Department of the Macmillan Company. Several of our professional friends gave us the necessary encouragement and backing to bring this about, and for this we wish to thank Dr. Robert Havighurst, Dr. Willard C. Olsen, Dr. Caroline Tryon, Dr. Harold E. Jones, and the late Dr. C. Anderson Aldrich.

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THE SIGNIFICANCE OF CHILD DEVELOPMENT

AMONG the many motives which impel mankind to action and to thought, few, if any, are as universal, as persistent, or as potent as the drives connected with the production, protection, and guidance of children. Generally speaking, these are the only drives which compete successfully with those connected with personal survival. About the growth needs of children and youth revolve the family and the school. To assist each child toward the fulfillment of his potential, many professional workers devote a large part of their life effort. To secure living and learning opportunities through which boys and girls may grow into self-respecting, useful, and socially responsible men and women, we adults give time and effort, and also contribute directly and in taxes a very considerable portion of our earnings.

This interest in the nurture and guidance of each oncoming generation is deeply rooted in the satisfactions of personal relationships. Among mankind it rests, also, upon the belief that the improvement of society as a whole depends largely upon how these successive generations are fashioned during the first two decades of life. Many thoughtful people believe that if there is to be one world it will be because that goal becomes an integrating life purpose for at least a majority of human beings. Life purposes arise from the intricate processes of development. Within broad limits, the kinds of men and women we become are determined, for each individual, by the continuous dynamic recombination of readiness and experience. At each stage in development this recombination gives direction to the ensuing stage. As parents, as physicians, as educators, as social engineers, we are committed to the belief that we can in some measure control the direction and scope of children's development. Many of us hope that in this way we may influence the course of societal evolution.

THE NEED FOR UNDERSTANDING THE HUMAN GROWTH PROCESS

Experience in controlling the phenomena of the physical world and the organic world in which and upon which we live has taught us that the

control of natural phenomena depends upon understanding them; that understanding and later control are achieved only through cumulative investigation of the pertinent aspects of these phenomena; that the scientific approach is essential to the fruitfulness of the investigation. The eradication of bubonic plague became possible only through the accumulated scientific knowledge of the complicated process by which it is spread, including the pertinent features of the life history of each of the several vectors concerned. In the fields of plant and animal culture modern miracles of adaptation to human use have been accomplished through the persistent application of scientific methods to the problems of growth and reproduction.

From this experience in modifying organisms of lesser complexity it seems reasonable to suppose that through the collection of pertinent data we may learn sufficient about the controlling dynamic factors determining the process of human development to be able to guide that process toward higher levels of personal satisfaction.

TENETS OF CHILD DEVELOPMENT RESEARCH

Ellen Key once said that the twentieth century is "the century of the child." Certainly in America during the last forty years increasing numbers of people have come to believe not only that we *should* know more about the dynamics of human development but that we *can* know more if we apply appropriate methods of study to the problems involved. Under the initial leadership of Bird T. Baldwin, Helen Thompson Woolley, T. Wingate Todd, Arnold Gesell, E. A. Bott, Lawrence K. Frank, and others, there has emerged a new field of research which has been designated "Child Development." The field of child development represents not only a renewed realization of the importance of studying growth during the crucial early years; it represents also a new approach to that endeavor. For a broad exposition of this new approach in research the reader should consult the numerous articles by Lawrence K. Frank.[1]

In data collection and analysis there are three general tenets in child development which are important for consideration in connection with our study of somatic development of boys.

The first of these is the importance of collecting data on the same individuals over a space of time if insight is to be gained into the process rather than the *fait accompli* of development. The ideal, of course, would be to study human beings over a series of generations as is done in studying the life history of the very accommodating rat. But Carrel has already pointed out the limitations of man studying man when he said, "Each of us can make but few observations. Our life is too short." [2] However, within more

closely defined time limits attempts are being made to make so-called "longitudinal" studies of children rather than the cross-sectional studies which captivated the enthusiasms of early students of child research in the first quarter of this century. The study of somatic development which we present here is one such attempt, based on the accumulated data collected on the same boys over a seven year period.

A second emphasis in data collection made in child development research is that studies should be planned so that data concerning many aspects of an individual's development are collected at the same time. The California Adolescent Study as a whole, as well as the part of it devoted to somatic development, was planned on this basis, and some indication of the variety of data collected is given in Chapter II.

This principle of simultaneous data collection is followed by a third general tenet: that analysis should attempt to bring these various aspects of development into an organic relationship. The purpose here is to try to increase our understanding of the "child as a whole" rather than to continue to consider him from the standpoint of the compartmentalized fiction of the academic disciplines of anatomy, physiology, and psychology. In discussing this point Olson says, "When one becomes interested in living human beings, measured structures and functions may be regarded as changing expressions and samples of a total organism which in its own right has unique characteristics." [3] Unfortunately, the degree to which the investigator can accomplish "simultaneity" of approach in considering or presenting different aspects of growth is rather strictly limited. In the analysis of the somatic aspects we have experimented with techniques for meeting this problem. Our study had the advantage that accrues when diverse serial data are collected and organized by the same investigators. They knew the subjects as persons. For the investigator the memory image of each boy includes images of the growth profiles and other data which belong to him. The study had the benefit, also, of unusually helpful photographic records, which, when arranged in series, made it possible to evaluate the significance of specific dimensional changes against a background image of the whole boy.

Child development research, with its new orientation, is still in the stage of general preliminary exploration. We are formulating hypotheses, searching for new methods of investigation, seeking appropriate ways in which to organize data, trying out unusual forms of presentation. As Frank has said: "The problem of child development shifts the interest from the relation between two variables measured in a large sample of children at one moment to the study of the developmental processes as revealed through many different observations and measurements on one child over a period

of years." This shift of interest entails the formulation of different concepts which are difficult to express in words, phrases, or other symbols whose meaning has been molded to fit the old concepts. An even more fundamental difficulty arises when one tries to present a complex total field of multiple relations in sentences, paragraphs, and chapters which must focus attention successively upon selected parts of the total field. Since these and other difficulties have tended to obscure some of the threads of purpose which run through this book, we believe it will be worth while to preview some of them briefly.

SOME OF THE PURPOSES OF THIS STUDY

One of the initial purposes was to study the dimensional growth of individual adolescent boys in a sample large enough to indicate the significance of individual differences. It was clear that the methods used in studying "man in the mass" tended to obliterate many such differences, and so precluded judgment as to their significance.

A second objective, closely allied to the first, was to discover whether during this period there were group similarities of somatic growth pattern in addition to the well-known puberal growth spurt. If found, such similarities might be used in the construction of a time-dimension scale with units representing successive phases or cycles of development. For many years research workers in child development have sought some such scale based upon the phenomena of growth instead of upon chronological age. Todd's [4] scale of skeletal age as determined from X-ray photographs represents one aspect of this search, but its units are expressed as functions of group averages of achievement at half yearly intervals. They do not separate the individual's growth process into intrinsically distinct phases. Other contributions to this problem have been based on the assumption that the successive stages of pubic and axillary hair development offered the most promising indices of progress toward maturity.[5] Shuttleworth [6] prepared a scale with the puberal apex ("age at maximum growth") as the central determining point, but the units are measured in terms of chronological time before and after that point. It was the hope of those who planned the study reported in this volume that it would contribute its share toward advancing the quest.

A third objective, which emerged as the data accumulated and were ordered for interpretation, involved the classification of the timing relations among specific identifiable growth phenomena as they occurred in the several aspects of somatic growth in each boy. For example, what patterns of timing relation occur among the puberal peaks for height and weight? What is the range of timing relations between the onset of the puberal

spurt in glans penis growth and the beginning of the puberal phase of muscular strength increase? Does any rating on Todd's scale of skeletal age consistently occur synchronously with the ending of the puberal phase of growth in stem length? These and many other questions dealt with in ensuing chapters arose from the pursuit of this general objective.

A fourth purpose was to determine whether individual patterns of somatic growth varied consistently with outstanding differences in such obvious traits as tallness, fatness, muscularity, long-leggedness, early development, etc. Data of this sort might be useful to those who wrestle perennially with problems of body build in relation to personality and to predisposition toward disease. Perhaps findings in this area might have even greater importance in clarifying our ideas regarding the suitability of using one component as a characterization of an inclusive developmental configuration.

DISCUSSION OF METHODS OF ANALYSIS AND PRESENTATION

Speaking generally, the methods of analysis and presentation used in this study belong to the simpler variety of well-known statistical and clinical procedures. It is our feeling that until methods are available which are specifically designed to treat the diverse data of growth in ways which fit the peculiar orientation of the child development field, it is sound policy to use the simplest and most widely understood of the existent methods.

For studying as well as for presenting configural relationships we found the comparison of like-scaled growth profiles particularly useful. Figure 1 shows at a glance how much more appropriate a *growth rate* profile is than a profile of *growth achieved* for analyzing a sequence pattern. Figure 2 shows the usefulness of this graphic device in discovering the corresponding growth phases among several aspects of development in the same individual. We predict that, when those who minister to a child's wholesome development realize more fully the usefulness of knowing where he is in his progress toward maturity and what is the rhythmic pattern of his growing, profiles of growth rate will be used much more widely than at present.

Another method of data analysis which we used seems to deserve special mention. This was the comparison of serial photographs. By arranging close together in age order the fifteen front view photographs of a boy, visual comparisons between adjacent pictures could be made with such rapidity that the viewer gained helpful hints as to the features and stages of change which might deserve special attention in quantitative terms. The intensive study of the early adolescent fat period as it occurred in our sample was first suggested by the photographic records. It was the study

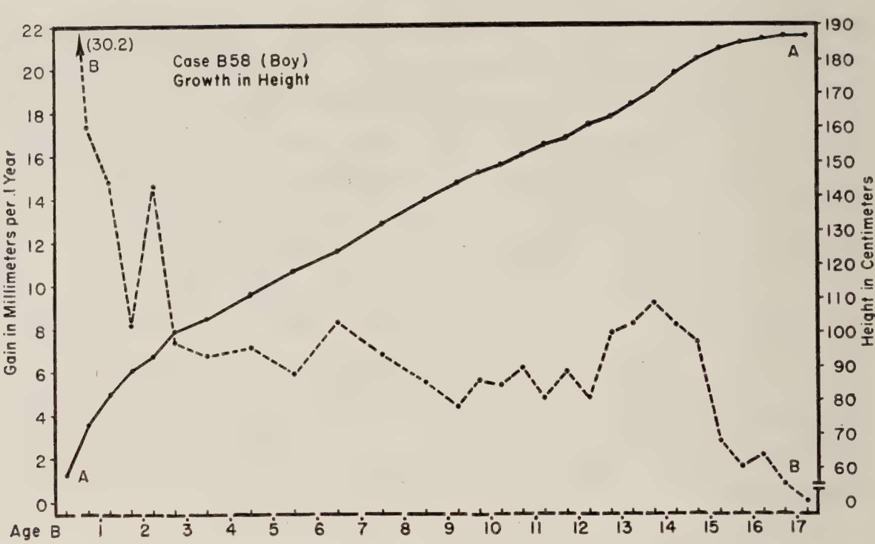


FIGURE 1. These profiles illustrate two ways in which the same growth data may be arranged and presented. Profile A shows how tall a boy was at successive chronological ages and what was the general trend of his growth. Profile B shows the changes in the same boy's growth rate during successive periods. Changes from acceleration to deceleration, or the reverse, and changes of gradients from one period to the next constitute the outstanding features of Profile B but are scarcely noticeable in Profile A. Even if they were magnified in A, by increasing the value of the scale units, the variations in rate would be less obvious than in B because of the cumulative nature of the growth achieved arrangement. Note particularly the distinctive features of this boy's sequential growth pattern for height as they are emphasized in Profile B.

of the serially arranged pictures which suggested a new approach to the old problem of how to determine specific developmental phases in the growth of the male genitalia without resorting to direct measurement, with all of the difficulties which that procedure would involve.[7] We are convinced that, just as Gesell [8] has adapted photographic techniques to his method of analysis of infant behavior, others in the field of child development will adapt them further to the analytic requirements of somatic growth studies of adolescent boys and girls.

THE RESEARCH OPPORTUNITIES WHICH ADOLESCENCE PRESENTS

The profiles shown in Figures 1 and 2 will remind the reader that human growth is never straight-line growth so far as the individual is concerned. Even disregarding fluctuations of brief duration, it is evident that between conception and maturity there is wide variation in growth rate. There are

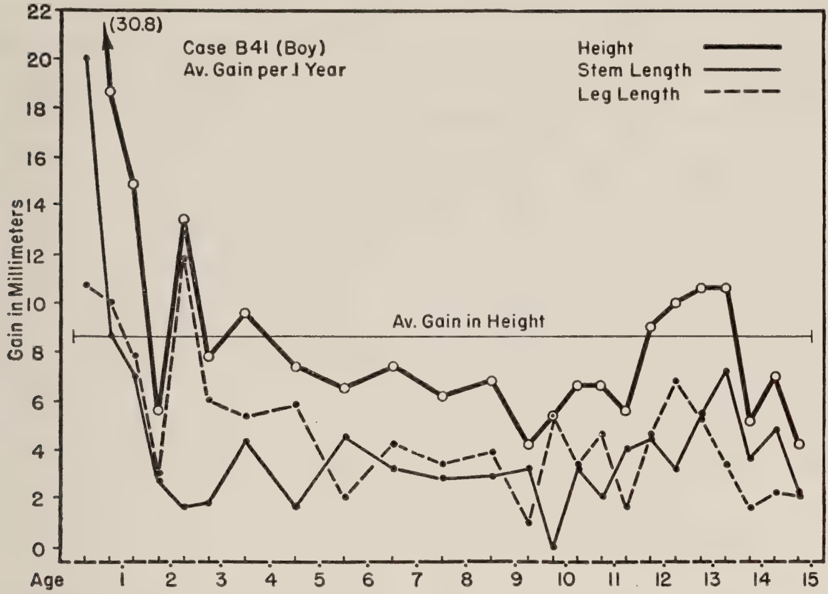


FIGURE 2. In this figure one may compare the growth rate profiles of height, stem length, and leg length for the same boy from birth to fifteen years. Note the asynchronous similarity of the configurations for leg length and stem length. During later childhood the leg length phase from five and one-half to nine and a quarter years obviously corresponds to the longer stem length phase from four and one-half to nine and three-quarters years. For the several phases of the puberal cycle, configural correspondences are even more striking. In this early developing boy the height profile shows greater tendency than usual toward phase correspondence with the other profiles.

two periods in life of rapid rise and fall in growth rate, each followed by a period with fairly constant growth rate level.

The first cycle begins with conception; the second cycle ushers in adolescence. The greater portion of the first acceleration-deceleration cycle occurs before birth. Only the last part of the cycle is represented in the profiles in Figure 2 as a phase of rapidly decelerating rate during the first few years of postnatal life. Obviously, it is not possible to apply the methods of a longitudinal study to this first manifestation of the cyclic growth phenomenon.

However, the second manifestation presents full opportunity for such research. The changes in rate of dimensional growth specifically associated with puberal development are great enough to be readily and reliably measured. With few exceptions the short-term fluctuations of rate do not obscure the primary pattern during the rapid growth of the puberal cycle as they are apt to do during the slow growing period of childhood and later adoles-

cence. This greatly facilitates the identification of corresponding points and phases in the growth profiles for the several dimensions. Furthermore, only during adolescence does the rapidity of change in body hair and external genitalia make it possible to distinguish clearly phases of sexual maturation which can be used as additional reference points for identifying the stigmata of progress in other aspects of development.

The greater rapidity of change which sets adolescence apart from childhood and from adulthood is but one of the advantages which it offers to the student of human development. A second advantage lies in the fact that adolescence is a critical period in the emergence of each boy's or girl's personality. During later childhood a child can enjoy his ever-increasing competence in daily living without thinking very much about himself, but with the onset of the prepuberal phase of adolescence he begins to become aware of new urges from within and new expectations from without. These focus his attention upon himself in unaccustomed relations to life and people, and especially to contemporaries of the other sex. In short, he has to deal with a new and urgent readiness in himself which is both intriguing and disturbing.[9]

With these personality changes somatic development is closely associated. The changes in his body become for him symbolic of the other aspects of his personality metamorphosis. Indeed, during the puberal phase of development the body seems to become the primary symbol of the self. In a previous publication we have discussed this phenomenon in detail, showing how frequently adolescents are disturbed over their physical peculiarities and the kinds of somatic differences which disturb them.[10]

A longitudinal study of adolescents, therefore, may yield particularly valuable data regarding fundamental personality characteristics of individual boys and girls because at that time each youngster is apt to experiment with new roles in the hope of finding a self that he can live with comfortably. The timing, magnitude, and synchrony of his body growth during the puberal cycle are important factors in determining not only the problems he faces but the extent to which he achieves self-acceptance. In the last chapter of the book we give an example of how somatic growth data may be used as the frame of reference for describing the social development of a boy for whom adolescence proved an especially critical experience.

FOOTNOTES FOR CHAPTER I

[1] In his introductory chapter to *Child Behavior and Development,* edited by Barker, Kounin, and Wright (McGraw-Hill Book Company, Inc., New York, 1943), Mr. Frank clearly defines the essential philosophy of the child development approach in its relation to other recognized fields of scientific research.

[2] Carrel, Alexis: *Man the Unknown.* Harper & Brothers, New York, 1935, p. 52.

[3] Olson, Willard C.: "Growth of the Child as a Whole," Chap. XII in *Child Behavior and Development,* edited by Barker, Kounin, and Wright, McGraw-Hill Book Company, Inc., New York, 1943.

[4] Todd, T. Wingate: *Atlas of Skeletal Maturation.* The C. V. Mosby Company, Medical Publishers, St. Louis, 1937.

[5] The pioneer in this approach was C. Ward Crampton. See reprint of his material in *Child Development,* **15,** No. 1: 51, 1944.

[6] Shuttleworth, Frank K.: "The Physical and Mental Growth of Girls and Boys Age Six to Nineteen in Relation to Age at Maximum Growth." *Monograph, Society for Research in Child Development,* **4,** No. 3: 1, 1939.

[7] See the discussion in Chapter XIV.

[8] Gesell, A.: *An Atlas of Infant Behavior.* Yale University Press, New Haven, 1934.

[9] The personality development of this period is ably discussed by Peter Blos in *The Adolescent Personality,* Appleton-Century-Crofts, Inc., New York, 1941.

[10] Stolz, H., and Stolz, L.: "Adolescent Problems Related to Somatic Variation." *43rd Yearbook,* Part I, National Society for the Study of Education, Chicago, 1944, Chap. V.

Chapter II THE CALIFORNIA ADOLESCENT STUDY

IN ORDER that the reader may see the study of somatic development of boys which is presented in this volume within the framework of the larger research project of which it was a part, we are giving a brief description of the California Adolescent Study. This research was begun in January, 1932. Data were systematically collected on the same children until the fall of 1938 and the spring of 1939.

THE CHILDREN

There were 105 boys and 111 girls included in the study at the beginning. A year later 7 boys and 10 girls were added, making a total of 233, of whom 112 were boys and 121 were girls. These children were all enrolled in the Oakland Public Schools at the time they were selected. They were in the high fifth and low sixth grades of five elementary schools. Children from these schools were selected in the hope of securing a relatively stable group who would be available for study throughout the seven years. The schools were located in adjoining residential districts with a comparatively low rate of school turnover. The pupils from these five elementary schools usually went to the same junior high school, and a high percentage went to the same senior high school. This prospect indicated greater ease in administering the study as years went on.

The children in May, 1932, ranged in age from 9.5 years to 12.5 years, 95 per cent being between the ages of 10 and 12 years. The median age was 11 years.

The intelligence of the group was measured in 1933 and again in 1935.[1] The average I.Q. for the group as a whole in 1935 was 110 with a standard deviation of 13.6. Table 1 presents a summary of the data for boys and girls separately.

The group was a fairly representative sample of the children in the fifth and sixth grades of the Oakland Public Schools, with the exception that it included no Negroes, no Orientals, and no Mexicans.[2] There were 11.56 per cent of the children who had a foreign-born mother or father or both.[3]

Family status. The study began when the families of these children were feeling the impact of the economic depression. Between 1929 and 1933 a drastic change had taken place in the incomes of many families.[4] In general, the families in 1929 were about equally divided between lower income groups ($2,500 and under) and middle and upper groups. The highest income was $17,100. However, in 1933 the range in yearly income was from $12,000 to 0 with 70 per cent below $2,556, whereas in 1929 only 47 per cent had been below that figure. In 1929 there were no families without income or where the father was on relief, but by 1933, 9 per cent were receiving state aid, were on relief, or were working on government relief projects.[5]

Table 1 INTELLIGENCE TEST SCORES

	Boys		*Girls*	
	1933	1935	1933	1935
Number of cases	92	87	103	90
Mean	114.70	113.30	109.50	106.20
Standard deviation	12.87	13.95	11.72	14.94
Range	87–147	67–143	79–143	63–136

The fathers earned their living through a wide variety of jobs, from professional occupations to unskilled labor. Of those employed in 1933 almost two thirds (64.46 per cent) were in professional and so-called "white collar" occupations, while Oakland's population included only 36.4 per cent in these categories.[6] The fathers who were skilled workers and foremen (23.49 per cent) were for the most part engaged in occupations which were strongly unionized in Oakland.

PROCEDURES

The data concerning the development of these boys and girls during the seven years of the study were collected in a variety of situations and covered a wide range of characteristics.[7] Until the children finished junior high school (ninth grade) they came twice a year to the Institute of Child Welfare at the University of California in Berkeley. Each week from the middle of January to the middle of May and from the middle of September to the middle of December from four to eight children were brought from school to the Institute. Boys and girls came on different days of the week. They came at nine in the morning, brought their lunches, and stayed until two in the afternoon. In general, the same group of children came together each half year. Later, when all the children were in senior high school, many of the data were collected at a portable building in the yard of the

high school where most of the children attended. This became known as the "Adolescent Cottage."

At the Institute and the Adolescent Cottage developmental data were collected from 1932 to 1939 by means of anthropometric measurements, medical examinations, body photographs, observations and ratings of behavior, and tests of intelligence, learning, achievement, and motor abilities. From time to time additional supplementary data of various kinds were secured.

One year after the beginning of the study (1933) a seriatim physiological study was begun with a subsample of fifty boys and fifty girls. Measurements were made (every six months for five years and annually thereafter) of basal metabolism and of body temperatures, respiratory rate, respiratory volume, pulse and blood pressure under basal conditions. In addition, metabolic respiratory and cardiovascular recovery rate following exercise were studied. Quantitative analyses were made of first morning samples of urine every six months. These experimental examinations were all made at the physiological laboratory of the University of California.[8]

The program for obtaining X-ray appraisal of bone development was not begun until 1936, when the children averaged fourteen years of age. Roentgenograms of the left hand and knee were taken at six month intervals on 90 boys and 87 girls over a period of four and one-half years. These X-rays were assessed according to the Todd standards.[9]

A clubhouse was opened in 1933 and maintained for the children in the study, for two years adjacent to the junior high school and for one year near the senior high school.[10] This clubhouse served several purposes. It was certainly a compensation for the time and cooperation the children gave to adults for the pursuit of their research interests. It also became a means of making and cementing social relations within the group. And finally it served as an excellent situation in which to observe the spontaneous activity, social behavior, and personal-social relations of boys and girls.[11]

After the clubhouse was closed, a series of excursions was planned in order to provide informal situations where children could be observed unobtrusively. Usually forty or more boys and girls attended these affairs which included a swim party, a week-end ski trip, and a week-end camping trip.

The elementary, junior, and senior high schools where the children attended provided many opportunities for the collection of data. Observations were made on playgrounds and in classrooms. Tests and questionnaires were administered in classrooms. Teachers made observations of behavior, and school reports and records were made available.

There were many contacts of various kinds with parents, both to secure home data and to keep in rapport with the family. Scheduled visits were made to the home of each child before the study began, again in 1934, and again in 1938.

The close relation with the school and the home were due in large measure to the fact that one member of the staff served as counselor to the children in the study during the whole seven years. She had previously been a counselor in the Oakland Public Schools and acted as school counselor for the students in the study while on the staff of the Adolescent Study. This counselor became intimately acquainted with each boy and girl and with many of their families. Her genuine friendship for the children and identification with them served to hold the group together socially through the years. This continuous contact of one person gave an opportunity for observing developmental changes as they occurred, and the insight thus gained has become an invaluable asset in providing a kind of human cement to integrate the data collected by more formal techniques.

There were a number of the staff who continued from the beginning of the study throughout the seven years and who knew these individual boys and girls as persons as well as in terms of their measurements and performances.[12] Through frequent conferences and many informal discussions among the members of the staff, the knowledge which each was collecting became constantly integrated into a more inclusive concept of each child's personality. These staff members also became a nucleus into which new members of the staff could be absorbed without jeopardizing the continuity of fundamental purpose and data collection.

THE DATA

The following outline indicates the wide variety of data which have been collected and shows the relation of the study of somatic development which is presented in detail in this volume to the total research program of the California Adolescent Study.

1. Records of physical growth
    a. Anthropometric measurements
    b. Photographic records
    c. Medical examinations
    d. Roentgenograms
    e. Basal and exercise physiological data
    f. Galvanometer tests
    g. Optometrical measurements
    h. Motor tests

2. Records of social and emotional development
   a. Anecdotal descriptions of social behavior during clubhouse activities, noon hour at the Institute, on excursions, and during other social situations
   b. Ratings of social behavior, emotional responses, and personality as observed at the Institute, at the clubhouse, during physical examination, and during experimental situations
   c. Responses to written inventories, questionnaires, and tests on emotional adjustment, social evaluation of self and classmates, interests, activities, vocational interests, and attitudes
   d. Records and informal comments on conversations and clubhouse attendance
   e. Descriptive comments and interpretations of test responses on Binet, Rorschach, and Murray Apperception
   f. Creative material: compositions, poetry, letters, paintings, drawings
   g. Reports of interviews
   h. Teachers' reports and comments
   i. Home data
3. Records of intellectual and educational development
   a. Learning tests
   b. Intelligence tests
   c. Achievement tests
   d. School cumulative record
   e. Teachers' ratings of school achievement

Analyses of this large body of data were begun while the study was still in progress and are continuing. In the following chapters reference will be made to specific reports as they relate to the discussion of somatic development.

FOOTNOTES FOR CHAPTER II

[1] Measured by the Terman Group Test, Forms A and B, given at about two week intervals (retest coefficient of correlation at two week intervals being .93).

[2] In the Oakland public school population there were about 2.4 per cent Negroes, 2.5 per cent Orientals, and 2.5 per cent Mexicans.

[3] Based on 182 cases active in 1936–1937, there were twenty foreign-born parents: nine from Italy, four from Scandinavian countries, two from England and Canada, and one each from Mexico, Armenia, Russia, Hungary, and Tahiti.

[4] For a more complete analysis from which this summary is taken, see manuscript on file at Institute of Child Welfare, University of California.

[5] In July, 1933, 7.4 per cent of the population of Alameda County where Oakland is located were on relief. *Review of the Activities of the State Relief Administration of California, 1933–1935,* San Francisco, 1936, p. 282, Table 6.

[6] As against 40.8 per cent for the United States as calculated by Alma M. Edwards, U.S. Bureau of the Census, 1933.

[7] Jones, Harold E.: "Procedures of the Adolescent Growth Study." *J. Consulting Psychol.,* **3:**177–80, 1939.

[8] Shock, Nathan W.: "Physiological Changes in Adolescence." *43rd Yearbook,* Part I, National Society for the Study of Education, Chicago, 1944, Chap. IV, pp. 56–79.

[9] Bayley, Nancy: "Skeletal Maturing in Adolescence as a Basis for Determining Percentage of Completed Growth." *Child Development,* **14,** No. 1: 1–45, 1943; "Size and Body Build of Adolescents in Relation to Rate of Skeletal Maturing." *Child Development,* **14,** No. 2: 47–90, 1943.

[10] Cameron, Jaffrey: "A Study of Early Adolescent Personality." *Progressive Education,* **15,** No. 7: 553–63, 1938.

[11] See section by Judith Chaffey in *Personal-Social Development of Boys and Girls* by L. H. Meek *et al.* Progressive Education Association, New York, 1940, pp. 218–226.

[12] These staff members included Judith Chaffey, Mary Cover Jones, Caroline Tryon, Nathan Shock, Frank Sawyer, Helen Pryor, Harold Jones, and Herbert Stolz.

Chapter III DESCRIPTION OF THE STUDY OF SOMATIC DEVELOPMENT OF BOYS

Section A METHODS USED IN COLLECTING DATA

THE data on the somatic development of boys were collected at the Institute of Child Welfare for the first four years and after that at the Adolescent Cottage. At each place a special room was set aside for the physical examinations with separate dressing room conveniently near.

GENERAL PROCEDURE

The measurements for the boys were taken throughout the study by two men physicians, with the assistance part of the time of a physiologist.[1] All measurements were recorded by an assistant on the Physical Examination Record Form.[2] Two boys came to the examining room together prepared for examination without clothing. While one physician was examining one boy the other physician examined the second boy. The general procedure was as follows:

Boy A	*Boy B*
Photographs by physician S	Medical examination by physician Z
Strength tests by physician S	Photographs by physician Z
Weight by physician S	Strength tests by physician Z
Medical examination by physician S	Weight by physician Z
Anthropometric measurements by physician S followed by physician Z	Anthropometric measurements by physician Z followed by physician S

ANTHROPOMETRIC MEASUREMENTS

All anthropometric measurements of the boys were taken in the nude.[3] The measurements were usually taken in the order in which they are described here. Each measurement was made on the boys by the two physicians, one after the other, while the boy was in the same position.

Weight was taken to the nearest tenth of a kilogram.[4] Fairbanks platform scales, calibrated in kilograms and tenths of kilograms, were used.

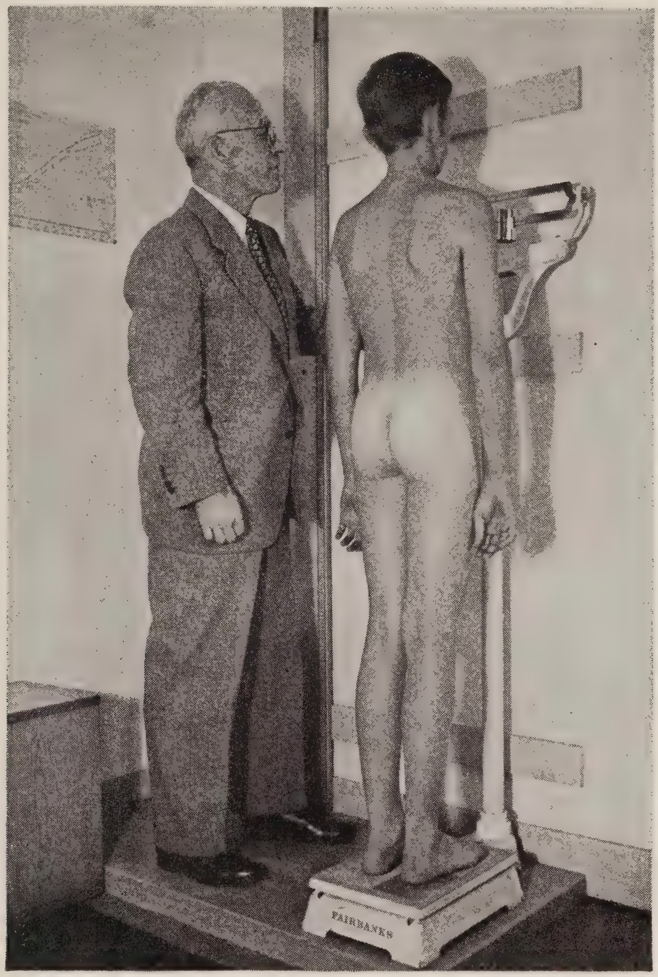


FIGURE 3. Weight was taken to the nearest tenth of a kilogram on Fairbanks platform scales. The balance of the scales at zero was checked on each examination day. Weight for each boy was taken by only one physician.

Standing height was measured with the subject standing with heels, buttocks, and head against an upright board. On this board had been pasted a paper scale in millimeters.[5] The Baldwin square [6] was modified by Stolz with a strip of wood along one edge of the vertical arm which, when pressed against the side of the measuring board, kept the lower surface of the square exactly parallel to the floor. The square was brought down firmly against the apex of the head. The subject was instructed to

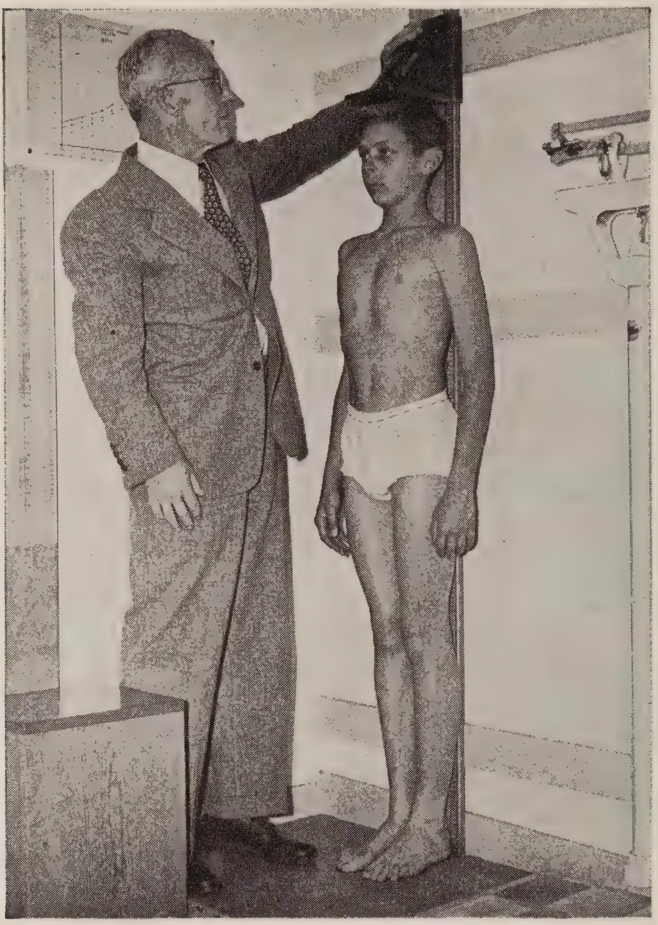


FIGURE 4. Measuring standing height. Note the modification of the Baldwin square by a strip of wood along the vertical edge which keeps the horizontal surface parallel to the floor. This apparatus yielded accurate measurements rapidly. Two examiners made independent measurements, one immediately after the other.

stand as tall as possible without changing the contact of his feet with the floor. Twice a year the paper scale was checked against a steel meter rod graduated in millimeters. Standing height as well as all other linear measurements were recorded to the nearest millimeter. (See Figure 4.)

Sitting height was taken against an upright scale similar to the one described for height. The subject was seated on a box 45 centimeters high with the buttocks, back, and head touching the upright scale. The measure-

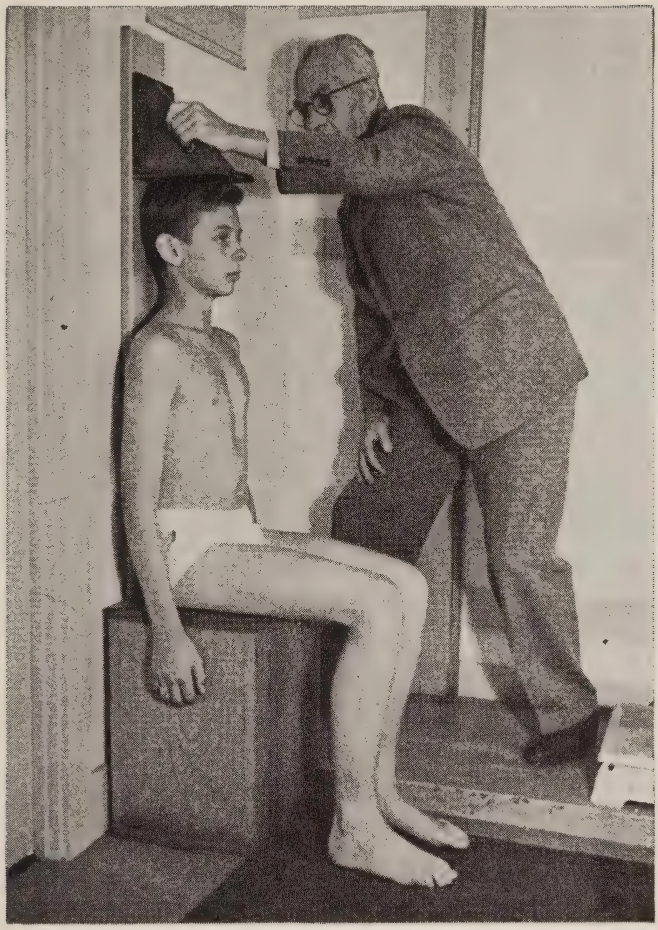


FIGURE 5. Measuring sitting height. The modified Baldwin square was used. Note that the upper plane of the thigh is approximately parallel to the floor, with the feet resting flat on the floor. This position differentiates the measurement from that of stem length shown in Figure 6.

ments for boys were taken with feet resting on the floor. The square was applied as in standing height. (See Figure 5.)

Stem length was taken with the subject seated on a box 45 centimeters high with his feet on a high rung of the stool. The subject's upper leg was at about a 25 degree angle from the floor. The directions for the boys' physicians stated, "When the child's feet are on the stool, have his leg at such a degree that it is not touching the box on which he is sitting. Always

FIGURE 6. In measuring stem length the upper leg is flexed to an approximate angle of 25 degrees from the floor line in order to secure a more accurate skeletal measurement than sitting height.

tell the child to lean forward with his head almost touching his knee, and then push himself back into position, sitting as tall as he can." Measurements were taken with the square from the crown of the head to the tips of the ischial spines. (See Figure 6.)

The difference between stem length and sitting height lies in the position of the thighs. In measuring sitting height the thighs are parallel to the floor, while in measuring stem length the thighs are flexed upon the trunk to an

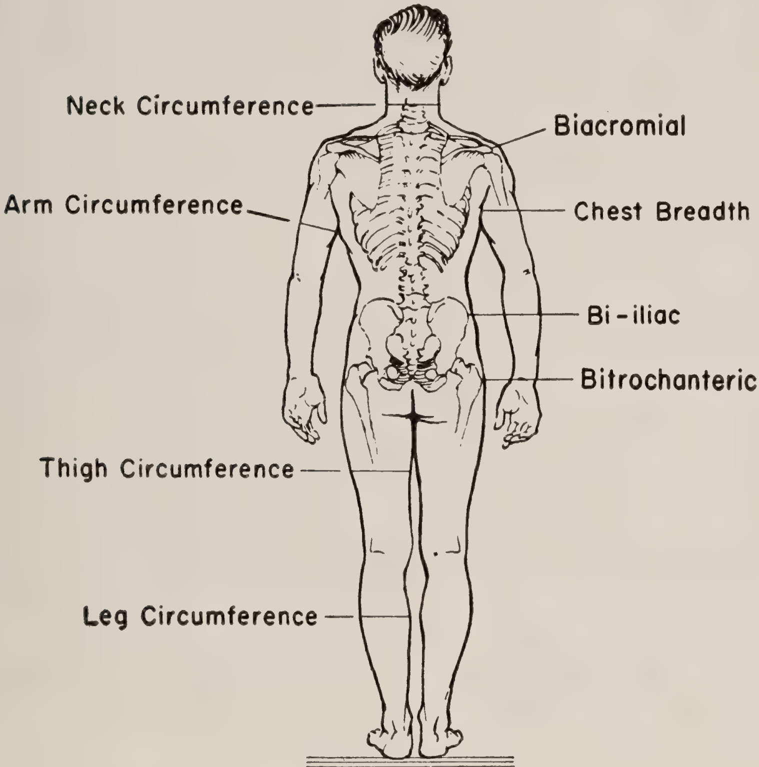


FIGURE 7. On this figure are indicated the points at which eight of the anthropometric measurements used in this study were taken. The measurements of the four diameters were determined with the sliding calipers (see Figure 8) from the points indicated to the corresponding points on the opposite side of the body. The circumference measurements were made with a linen tape with spring handle. (See Figure 8.) For detailed description of the technique, see the text.

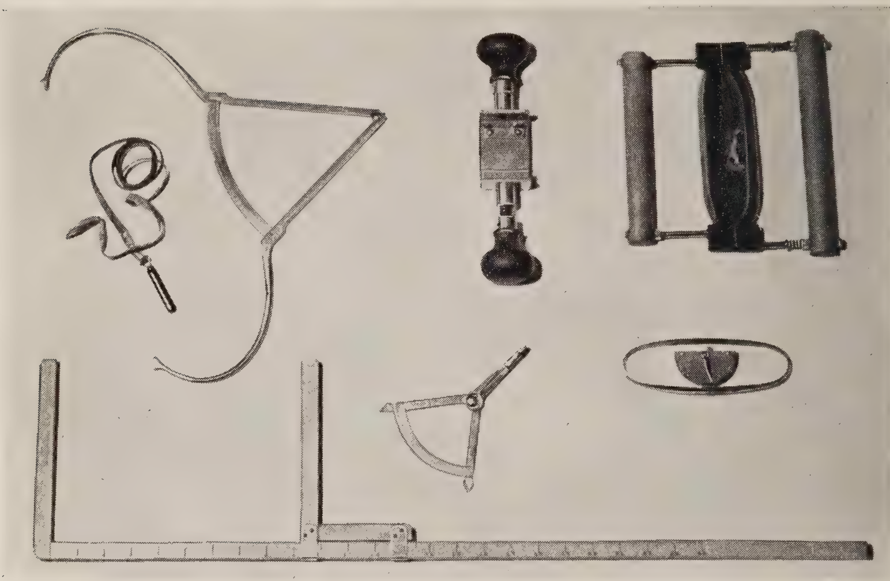


FIGURE 8. Instruments used in anthropometric measurements. There are three calipers: the sliding calipers made of wood used for measuring hip and shoulder width; the large spreading curved arm calipers for measuring chest depth; the small tissue calipers for measuring subcutaneous tissue.

The linen tape, equipped with a spring handle to ensure approximate constant tension, is used to measure circumferences.

The dynamometer measures hand grip. When placed in the larger frame to the right above, it is used to measure shoulder pull; when placed in the frame with knob handles, it is used to measure shoulder thrust.

The wooden sliding calipers and the linen tape were regularly calibrated against steel measures. During the period of seven years the calipers remained consistently accurate, the linen tape was replaced several times.

approximate angle of 25 degrees from the floor line. Stem length technique is used in an effort to secure a more accurate measurement of the bony skeleton with a minimum of other tissues.

Biacromial width was measured from the rear with the hands of the subject hanging straight at the sides. The sharp borders of the acromial processes were palpated from behind forward and measured firmly with the sliding calipers. In boys' measurements the calipers were held at an upward slant. (See Figure 9.)

Transverse chest width was taken from the front with sliding calipers at the nipple level, the instrument being parallel to the floor. The movable

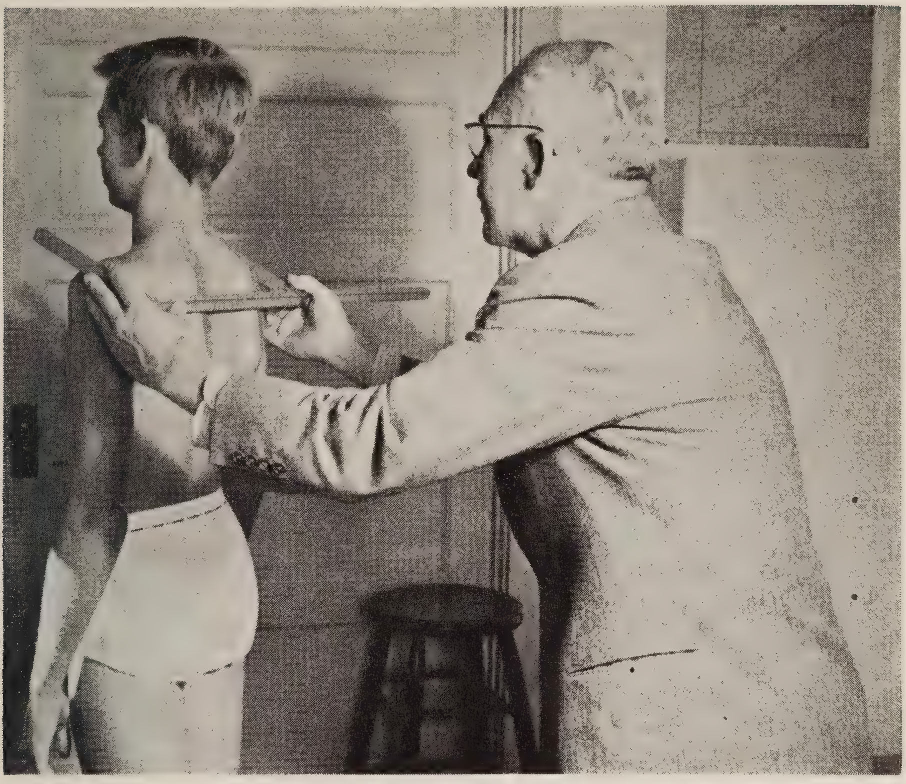


FIGURE 9. Measuring biacromial width with sliding calipers pressed firmly against the acromial processes. The mobility of the shoulder girdle and dependence of the measurement upon the position of the arms increase the difficulties of securing strictly comparable measurements at successive examinations.

arm of the calipers was held gently against the ribs and allowed to move with respiration. The minimum and maximum measurements were read, and the chest width was recorded as the mid-point between these measurements. The difficulty of securing reliably comparable measures from one examination to the next is obvious.

Bi-iliac width was measured with sliding calipers, using firm pressure to get as nearly as possible a skeletal or bony measurement of the widest flare of the iliac crest. These points were first determined by palpation. For the boys, the measurement was taken from the rear, holding the sliding caliper quite tight at a downward slant. (See Figure 10.)

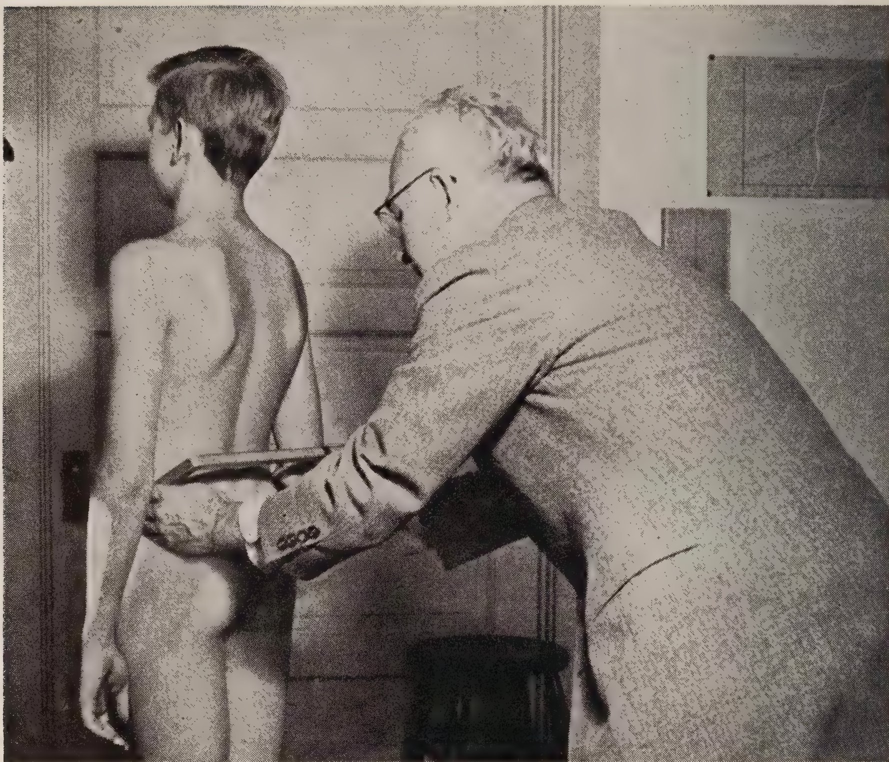


FIGURE 10. Measuring bi-iliac width with sliding calipers. The arms of the calipers were held in position to secure a measurement of the maximum distance between the iliac crests. By firm pressure of the caliper arms the interference of subcutaneous tissue in the accuracy of the measurements may be minimized.

Bitrochanteric width was measured by the same technique as for the bi-iliac measurement, care being taken that the feet of the subject were together and parallel. (See Figure 11.)

Chest depth, or anterior-posterior chest diameter, was measured with the spreading calipers at the junction of the fourth rib with the sternum,[7] the instrument parallel to the floor. The reading was taken midway between maximum and minimum depth during quiet respiration. This measurement is also subject to inaccuracies because of respiration. (See Figure 12.)

Neck circumference was measured, as were all girths, with linen tape equipped with a spring handle to ensure approximately constant tension.[8] The neck circumference was measured parallel to the floor at a point just

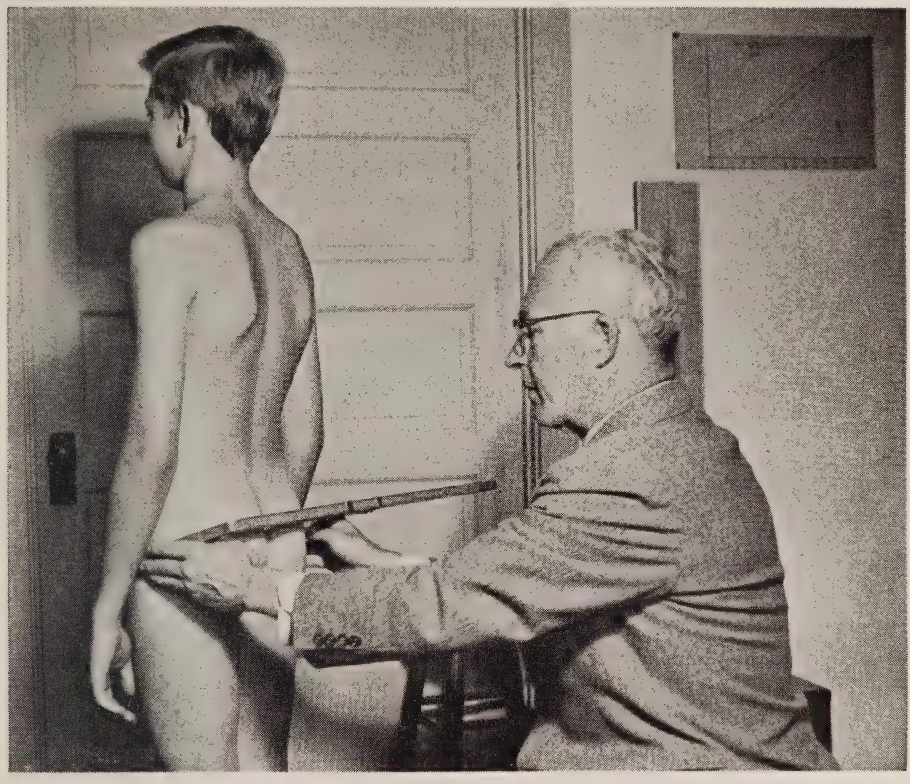


FIGURE 11. Measuring bitrochanteric width. The arms of the sliding caliper were firmly pressed against the external surfaces of the trochanteric processes. For accurate measurement it is necessary that the feet be placed parallel and as closely together as possible. In boys there is usually very little subcutaneous tissue over the trochanteric processes.

above the thyroid cartilage. Since this is not a skeletal measurement, it is affected by variations in muscular and fatty tissue as well as by growth in the thyroid cartilage. (See Figure 7.)

Chest circumference was measured with the linen tape with spring handle in a plane determined by the nipples in front and by points just below the lower tips of the scapulae behind. The measurement recorded was the point midway between the reading at the end of inspiration and at the end of expiration during normal, quiet breathing.

Upper arm circumference was measured with the subject in the standing position. The measurement was taken on the left arm with the arm hanging relaxed at the side. It was taken in a horizontal plane at the maximum bulge of the biceps muscle. (See Figures 7 and 13.)

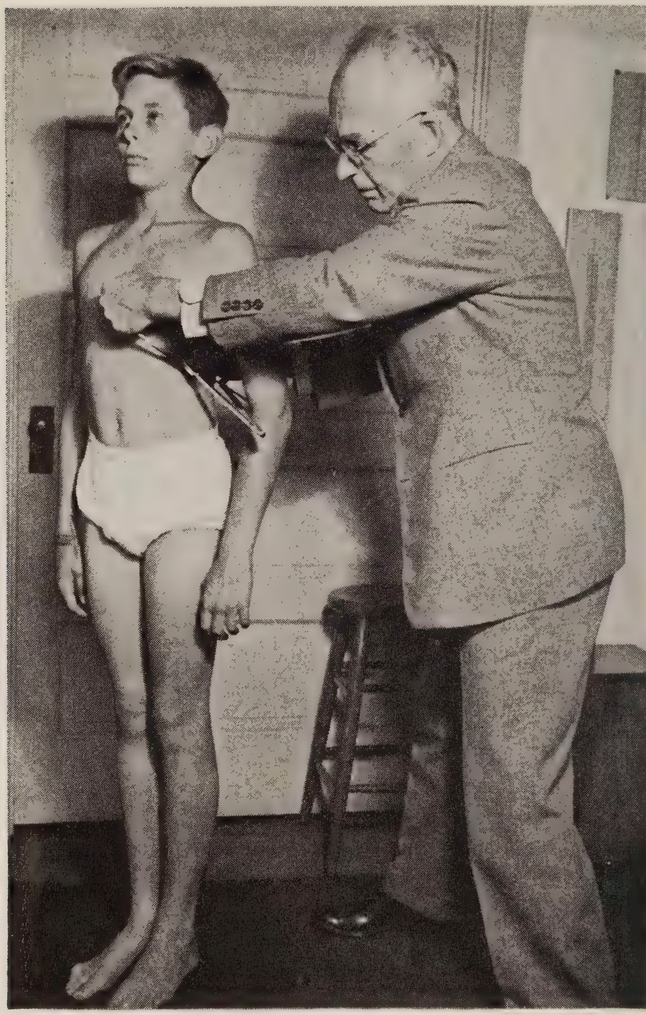


FIGURE 12. Measuring chest depth with the spreading calipers at the junction of the fourth rib with the sternum. The calipers were held so high that the line from tip to tip was approximately horizontal. Because of the difficulty of securing consistently reliable measures of this dimension it has not been found useful in analyzing growth changes.

Thigh circumference was measured with the subject in the standing position. The measurement was taken in a horizontal plane on the left leg halfway between the anterior-superior spine of the ilium and the upper border of the patella. (See Figure 7.)

Leg circumference was measured with the subject in the standing position. The measurement was made on the left leg in a horizontal plane at

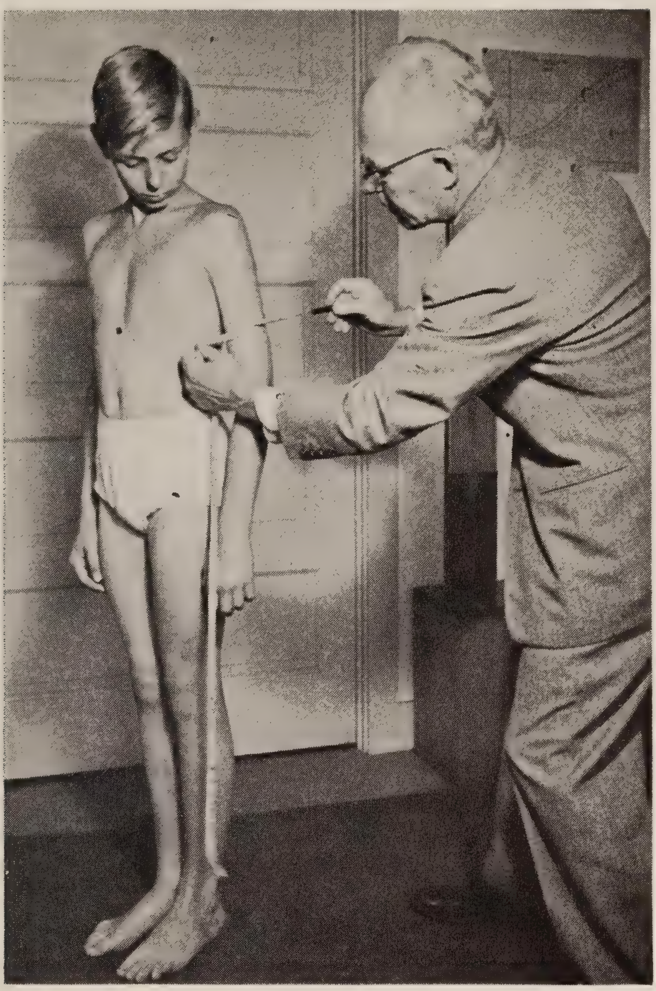


FIGURE 13. Measuring upper arm circumference at the maximum bulge of the biceps muscle, using tape with spring handle. By a similar technique circumference measurements were also taken of the left thigh and of the left calf as indicated in Figure 7.

the level of the maximum bulge of the muscles of the calf. (See Figure 7.)

Amount of subcutaneous tissue was measured during the medical examination while the subject was sitting on the examining table. It was measured with the subcutaneous tissue calipers devised by Franzen.[9] The sampling measurements were made in three areas: on the anterior surface of the left arm over the biceps region; on the abdomen on the left of the umbilicus; on the left side over the crest of the ilium. (See Figure 14.)

FIGURE 14. One of the three measurements of thickness of subcutaneous tissue made with the calipers devised by Franzen. In this study the measurement was taken with the subject sitting on the examining table rather than standing as illustrated in the photograph. The other measurements of subcutaneous tissue were made over the left biceps and over the left iliac crest.

Muscular strength was sampled by the following measurements: hand grip, shoulder pull, and shoulder thrust.

Hand grip was measured with the subject seated on a stool beside a table. The hand dynamometer [10] was grasped and squeezed without removing the elbow from the surface of the table. The subject was free to move the hand and upper arm, but care was taken to prevent the hand from being pressed against the table. Three successive trials were made with each hand with an interval of approximately thirty seconds between the trials. The maximum score for each hand was recorded. (See Figure 15.)

Shoulder pull was measured with the subject standing and with elbows at shoulder height. The dynamometer frame [11] was held in front of the

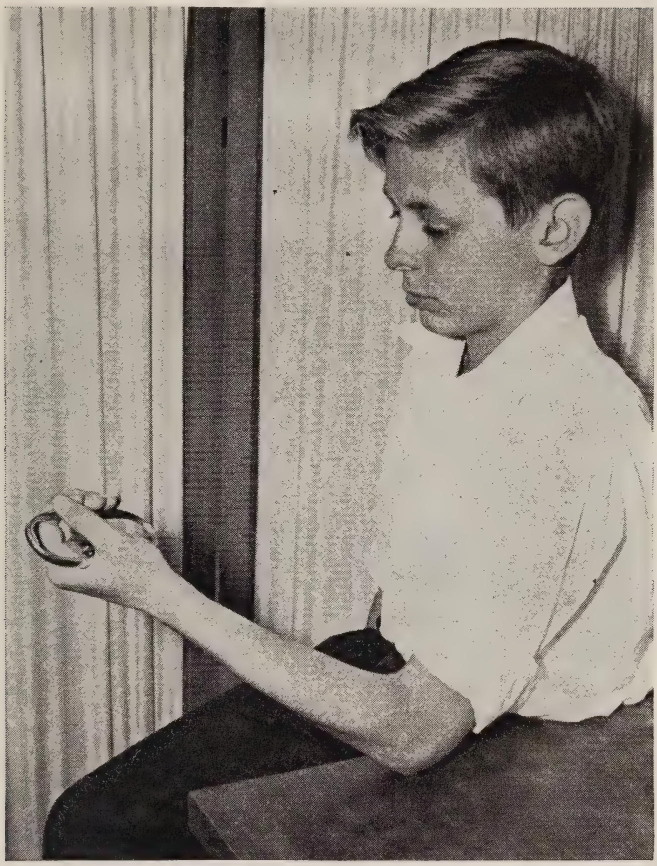


FIGURE 15. Measuring hand grip strength with the Collins dynamometer. The subject was required to keep his elbow on the table and his hand in the air but otherwise was permitted free choice of arm position. The boys were more interested in hand grip strength than in any other measurement of their growth.

chest and close to it. In making the pull, the subject was allowed to sway backward or forward and to rotate the forearms into the most effective position. Three successive trials were made with approximately thirty second intervals between trials. The maximum score was recorded. (See Figure 16.)

Shoulder thrust was measured with the subject in the same position as in shoulder pull, using the special thrust dynamometer.[12] The subject was encouraged to lean forward and hold elbows forward so that the instrument was held firmly against the chest. Three successive trials were made with approximately thirty second intervals between trials. The maximum score was recorded. (See Figure 17.)

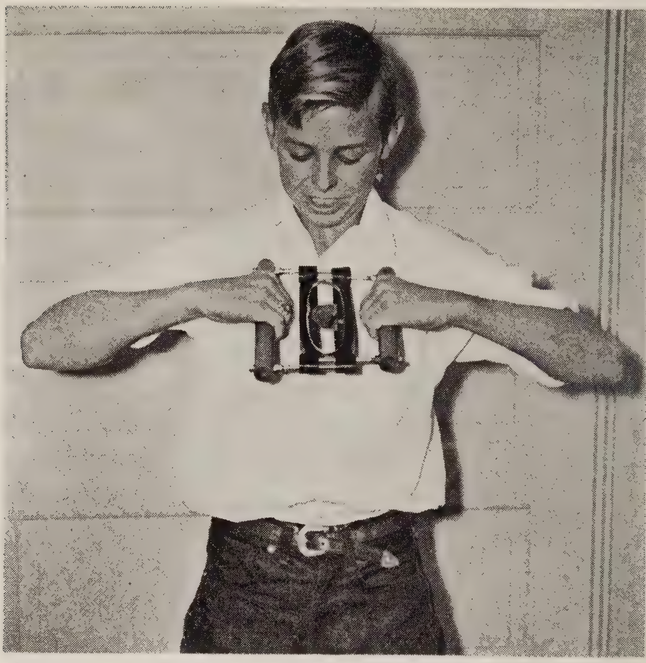


FIGURE 16. Measuring strength of shoulder pull.

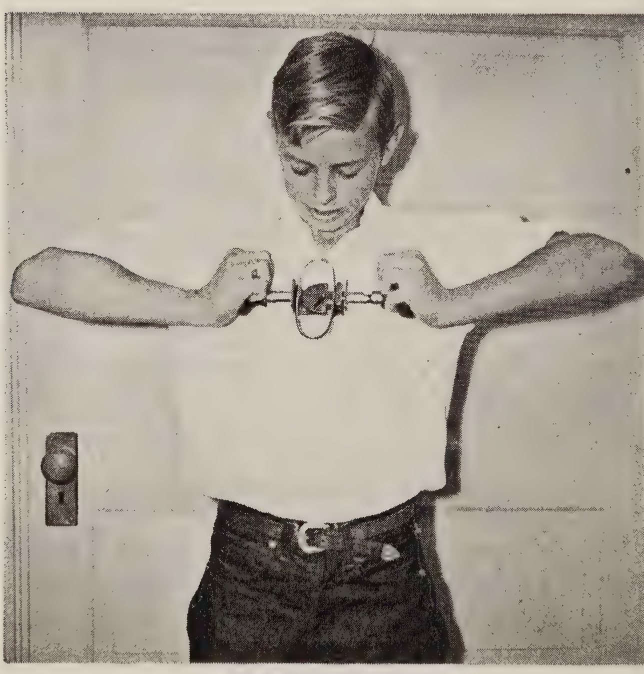


FIGURE 17. Measuring strength of shoulder thrust.

Reliability of the anthropometric measurements. All anthropometric measurements were made independently by two physicians. Where measurements disagreed by one centimeter or more, the measurements were repeated. For three years a physiologist, expert in anthropometric measurements, also measured the boys, which provided a means of checking on the accuracy of the two physicians. At the fourth examination (Fall, 1933) a statistical analysis of the reliability of the paired anthropometric measurements was made.[13] The coefficient of correlation between the measurements of either physician and the physiologist for the boys ranged from .999 for height to .934 for chest depth (Table 2). For those eight measurements used as a basis for the analysis of somatic development which follows, the coefficients of correlation ranged from .999 to .978.[14]

Table 2 COMPARISON OF ANTHROPOMETRIC MEASUREMENTS BY INDEPENDENT EXAMINERS

	Boys (Fall, 1933)				*Pearson*
	Mean		Standard Deviation		r
	Examiner R or Examiner Z Millimeters	Examiner K Millimeters	Examiner R or Examiner Z Millimeters	Examiner K Millimeters	Examiner K Examiner R or Examiner Z
Height	1510.0	1511.0	78.1	78.2	.999
Sitting height	784.1	784.6	40.7	40.9	.980
Stem length	773.1	772.7	39.0	38.9	.995
Biacromial	317.4	316.9	18.4	18.6	.987
Bi-iliac	239.3	239.4	15.7	15.8	.978
Bitrochanteric	267.7	268.5	18.7	18.6	.976
Chest breadth	229.6	227.0	13.9	13.6	.944
Chest depth	156.0	155.3	12.5	11.9	.934
Neck circumference	289.5	290.2	16.4	17.3	.969
Chest circumference	712.2	708.9	46.8	48.7	.978
Arm circumference	212.4	212.6	21.1	21.5	.983
Thigh circumference	439.9	439.9	43.3	42.3	.987
Leg circumference	302.4	302.4	24.1	24.1	.988

Another approach to the reliability of the measurements is through a study of the distribution of differences in the independent measurements recorded by two or more examiners. Table 3 gives for each variable the mean difference and the S. D. of the distribution of differences. From this the next table has been determined, Table 4, which estimates the possible error of measurement.

MEDICAL EXAMINATION

The purpose of the medical examination was to determine the general health status of the subject, noting any postural abnormalities, skin abnormalities, evidences of malnutrition, and cardiac abnormalities. During

Table 3 MEANS AND SIGMAS OF DIFFERENCES IN ANTHROPOMETRIC MEASUREMENTS

	Boys (Fall, 1933)	
	Mean Millimeters	Standard Deviation Millimeters
Height	.73	.74
Sitting height	1.09	1.00
Stem length	1.13	1.12
Biacromial	2.29	1.85
Bi-iliac	2.00	1.63
Bitrochanteric	1.95	1.46
Chest breadth	2.89	2.43
Chest depth	1.97	1.53
Neck circumference	2.59	1.82
Chest circumference—nipple level	4.25	3.34
Arm circumference	2.35	2.71
Thigh circumference	3.09	1.96
Leg circumference	2.00	1.45

Table 4 RELIABILITY OF ANTHROPOMETRIC MEASUREMENTS AS ESTIMATED FROM PAIRED MEASUREMENTS (*Fall 1933*)

	Chances are 68 in 100 that a second measurement will not differ by more than:	Chances are 98 in 100 that a second measurement will not differ by more than:
	Boys Millimeters	*Boys* Millimeters
Height	± 3.50	± 8.14
Sitting height	± 8.14	±18.96
Stem length	± 3.89	± 9.05
Biacromial	± 2.99	± 6.96
Bi-iliac	± 3.30	± 7.68
Bitrochanteric	± 4.05	± 9.44
Chest breadth	± 4.49	±10.45
Chest depth	± 4.25	± 9.90
Neck circumference	± 4.27	± 9.96
Chest circumference Nipple level	±10.16	±23.67
Arm circumference	± 3.95	± 9.20
Thigh circumference	± 6.80	±15.84
Leg circumference	± 3.72	± 8.67

the examination the development of public and axillary hair was rated and the number of permanent teeth was counted.

The medical examination was given by one physician and recorded by him on blanks especially prepared for this study.[15] Following the third

examination (Spring, 1933) comparisons were made between ratings on the first and second examinations, between ratings on the second and third examinations, and between ratings on the first and third examinations. On the basis of this analysis certain items which showed significant differences in ratings and which were of questionable value for the study or items which might be obtained more accurately from other sources were omitted from subsequent medical examinations. These items are indicated in the two forms for recording the medical examination to be found in Appendix A. The following description of method includes only the items retained in the medical examination.

Posture. The subjects were rated as they stood in their characteristic positions.[16] They were rated good, fair, or poor, according to the scale of photographs of boys and girls in "Posture Standards, Children's Bureau, U. S. Department of Labor, 1926."

Knee alignment was rated from behind with the subject standing. The examiner judged the alignment as being genu varus (bowlegged), straight, or genu valgus (knock-kneed).

Foot alignment was rated from behind with the subject standing with feel parallel. The examiner rated the feet as supinated (standing on outer edges), straight, or pronated.

Scapulae, right and left, were rated according to the Graves' technique.[17] Each scapula was inspected and palpated and its mesial border described as being convex, straight, or concave.

Handedness. Children were asked, "Which hand do you eat with?" "Which hand do you throw with?" and "Which hand do you write with?" This was asked at each of the first three examinations. If the information was consistent, no further checks were made. On this basis, the subject was classified as right-handed, left-handed, or ambidextrous.

Eyedness. A card approximately four inches by five inches with a hole one-half inch in diameter in the center was given the subject. The examiner closed one eye and placed his forefinger just below the open eye. The subject, standing at a distance of five feet from him, was told to look steadily at the examiner's finger, and while doing so to raise the card held in both hands at arm's length directly in front of him until he could see the examiner's finger through the hole in the card. The examiner recorded which eye the subject was using. This test was given at the first, second, and fourth examinations. (See Figure 18.)

Acne. If acne were found present, it was recorded as slight or severe, and the location of the lesions was recorded.

Birthmark. The size, description, and location of any birthmark was recorded at the first examination and checked at subsequent examinations.

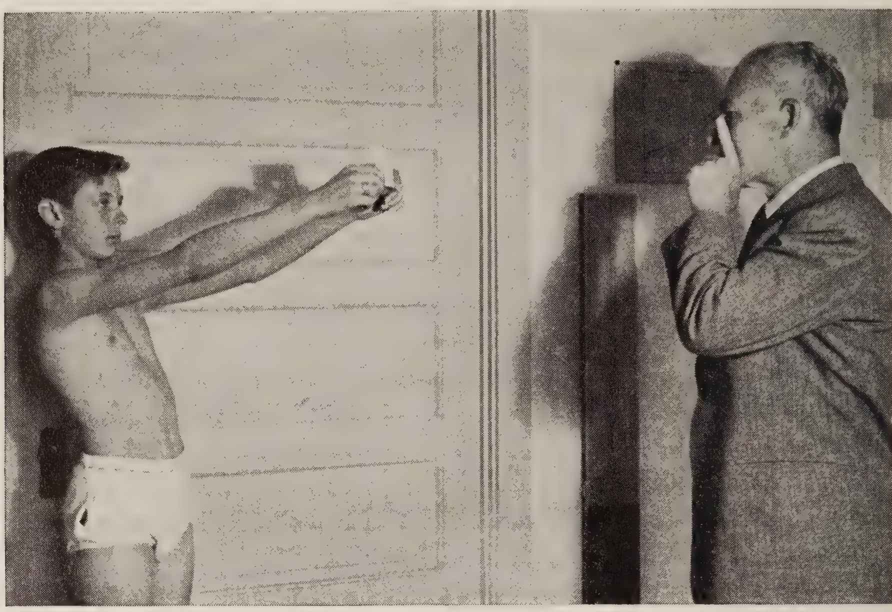


FIGURE 18. Testing whether the subject gives preference to right or left eye for seeing at distance of five feet.

Hair. Axillary and pubic hair were rated at each examination for boys and girls on the Davenport Scale [18] as follows:

Pubic Hair Development Rating Scale:

0. No differentiated pubic hair.
1. Down 2–3 mm long. Unpigmented.
2. Semi-terminals. 4–10 mm long. Rapid growth of the down, only slightly pigmented.
3. Terminals. Not over 25 mm long, sparse, fully pigmented, usually wavy.
4. Terminals. Same as 3, only full density.
5. Fully developed, dense, frequently curly hair over 25 mm long.

In this study the Davenport scale was extended to include a rating of 6. Rating 6 was given upon the basis of an obvious increase *in the area covered* by fully developed pubic hair. Sometimes the area was extended laterally, sometimes upward along the mid-line toward the umbilicus. For photographs illustrating the differences between ratings, see Figure 160 on pages 317-21.

Axillary Hair Rating Scale:

0. No differentiated axillary hair.
1. Down. 2–4 mm.
2. Semi-terminals. 5–10 mm.
3. Terminals. 10–24 mm. Sparse.
4. Terminals. 25 mm and over. Dense.

Bones. Any significant enlargement of the epiphyses, suggestion of rachitic rosary, or any bony deformity was recorded.

Lymph nodes. At each examination the cervical, submaxillary, axillary, and inguinal lymph nodes were palpated and their size was rated on a six point scale of 0 to 5. They were also described as hard, soft, or fluctuating.

Nose. At each examination the nostrils were examined for any evidence of discharge or obstruction, and any asymmetry of the nasal septum was recorded.

Pharynx. At each examination the pharynx was inspected for any evidence of injection, granulation, or discharge.

Tonsils. At each examination tonsils were rated as to size on a six point scale of 0 to 5. They were inspected for any evidence of injection or exudate. If they contained crypts or were buried, this was recorded.

Ears. The external canal and the eardrum were examined with an auroscope. Any wax obstruction, injection, discharge, or perforation was recorded.

Eyes. At the first examination a record was made of ptosis or strabismus. At each examination the eyes and eyelids were inspected for any evidence of injection, granulation, or other abnormality. Record was made of any use of eyeglasses.

Thyroid. At each examination the thyroid was palpated and rated on a six point scale from 0 to 5 as to size.

Heart. At each examination the area of cardiac dullness to percussion was determined. The heart sounds were auscultated with a stethoscope. Any arrhythmia or valvular murmur was noted and described. Any difference in accentuation between the aortic and pulmonic valve sounds was recorded.

Abdomen. With the subject lying on the examining table, the contour of the abdomen was noted and recorded as convex, flat, or concave. The position of the liver and the spleen were determined by palpation, and search was made for any points of tenderness. With the subject standing, the inguinal canals were palpated for any evidence of hernia.

Extremities. Any abnormalities of arms or legs were described.

Teeth. At each examination, all temporary and permanent teeth which had erupted were recorded. Evidences of caries, fillings, and extractions were recorded, as were also evidences of dental deformity.

Blood pressure. Blood pressure was taken with the subject lying on the examining table. The systolic and diastolic blood pressure were taken with a Tycos sphygmomanometer.

Personality rating. At the close of the physical examination after the subject had left, each physician filled out a personality rating sheet. The

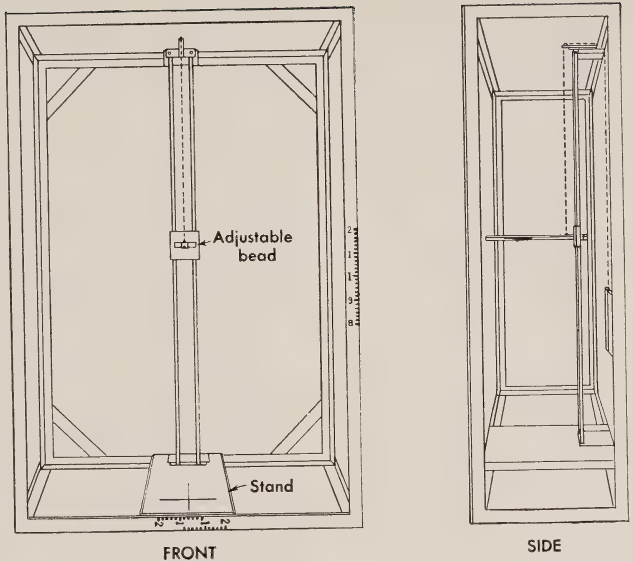
items were rated on a seven point scale and included beauty of face and coloring, pleasantness of facial expression, attractiveness of physique and carriage, masculinity-femininity, restlessness, and talkativeness.[19] In August, 1933, pictures were selected of those children rated as being extremes on the first four items as a guide to future ratings.

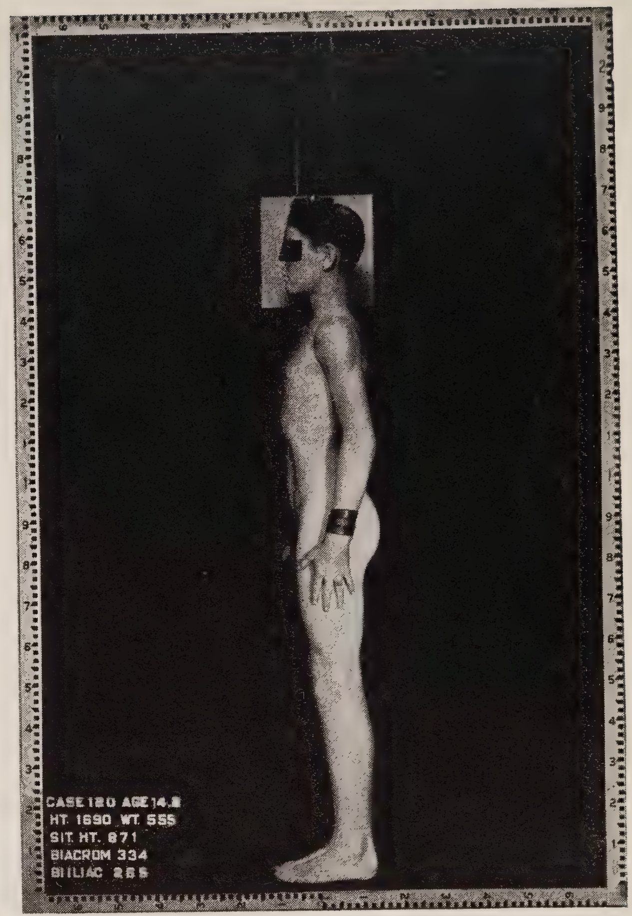
PHOTOGRAPHS

At each examination period the subjects were photographed under standardized conditions designed to secure photographs of the same dimensional scale. The individual stood in the photographic frame designed for taking standing height as illustrated in Figures 19a and b. The photographs were taken with a fixed-focus camera especially built for this purpose.[20] The camera box was mounted upon a sturdy frame fixed to the floor in such a position that the surface of the photographic plate was approximately eighteen feet from the front of the photographic frame and approximately four and one-half feet from the floor. At the beginning and for several years the photographic negatives were made on glass plates. Later, and after experimentation, films were used instead of glass plates. This was done in the interest of more compact filing, since it was found that the uniform scale could be obtained as well with films as with plates. The size of the photographic negatives was five inches by seven inches.

The problem of securing illumination which would bring out with equal clearness all parts of the body surface and which at the same time would bring out the body contours through contrast between light and shadow was a difficult one. Three and later four electric lights with reflectors mounted on movable standards were used. Preliminary experimentation determined the first arrangement and amperage of these lights. But as the study progressed, the placement of these lights was altered on the basis of experience until the combination which gave the best photographs was found. Thereafter, the lights were placed in these standardized positions.

The photographic frame was 2.1 meters high, 1.4 meters wide, and .66 meter deep. It was made of two inch angle iron welded at the joints. Built in at the back of the frame were two vertical round steel rods (two centimeters in diameter). These extended from the base to the top. These rods supported and guided a horizontal 2.5 centimeter square metal bar which extended from the back to the front plane of the photographic frame. Fifteen centimeters from the front end of the bar there was a metal crosspiece ten centimeters long. This bar was counterbalanced so that it could be adjusted to varying heights. A plank of hardwood was built into the base of the frame from rear to front to serve as a standing platform.





FIGURES 19a and b. Line drawing of photographic frame; and photographic frame in use.

A cross was painted on the platform, the intersection of the cross being directly below the intersection of the horizontal bar with its crosspiece.

Surveyors' linen tape, graduated in centimeters, was glued on wooden strips five centimeters wide. These strips were affixed to the four front pieces of the metal frame.

A black velvet curtain was hung on the back of the frame to serve as a background for the subject being photographed. In order to bring out the contours of the head, a gray cardboard thirty centimeters square was fixed to the adjustable horizontal arm.

The whole frame was painted black. On the front end of the horizontal bar a white dot was painted so as to be easily identified in each photograph. The cross on the floor was also painted white. (See Figures 19a and b.)

The subject stood beneath the adjustable rod so that when the examiner lowered the rod the intersection point on the rod touched the highest point on the subject's head. The subject was told to stand as tall as possible, but with feet in full contact with the floor. The subject was then directed to place his feet on either side of the mid-line of the white cross on the platform with his insteps over the intersecting line. When his body was in position and he was standing comfortably, the adjustable rod was made stationary with a hand screw.

Front, side, and rear views were taken of the subject at each examination, the horizontal bar remaining at the same height for each position.

Identification data and certain of the anthropometric measurements recorded at the same examination were photographed with each exposure.

Figure 20 is a sample of a complete series of photographs taken of one boy. These photographs have been reduced in size from the original five inches by seven inches and trimmed so that the photographic frame does not show.

Seriatim photographic records, so taken and arranged that they present to the student of human development comparably scaled visual images of the bodily appearance of a boy or a girl at successive stages of growth, yield valuable information which cannot be brought to life from verbal descriptions or from recorded measurements.

Each series shows not only the obvious developmental changes in height, shoulder breadth, hip width, body proportions, and postural alignment but also changes in the amount and distribution of subcutaneous fat, changes in the muscular development, and changes in the development of primary sex-appropriate characteristics—all constantly related to each other and to the unique body configuration of the person in whom they occurred.

Such photographic records are at present relatively rare; it is regrettable that the practical limitations of publication make it impossible to present the complete series which is available for each of the adolescent boys studied.

EXAMINATION SCHEDULE

The initial examinations were given for six boys on January 21, 1932. Initial examinations of the first sample extended from January 21 to May 12, 1932.[21] In addition, seven boys were given first examinations one year after the study began in order to compensate for cases which had terminated.[22]

Subsequent examinations were planned for every six months with a .5 year interval between examinations. Actually, there were many exigencies which interfered with this schedule—illness, absence from school, school holidays, other appointments which the children had scheduled, emotional disturbances, and sometimes what seemed to adults to be the desire of adolescents to run their own lives. The net result can be seen in Appendix D where the interval between successive examinations for each case is given.

The final examinations were given in the fall of 1938 and the spring of 1939 at the respective times when the upper and lower classes graduated from high school. It will be seen later that not all children had completed growth at that time, and it is to be regretted that examinations could not have been continued longer for those immature children.

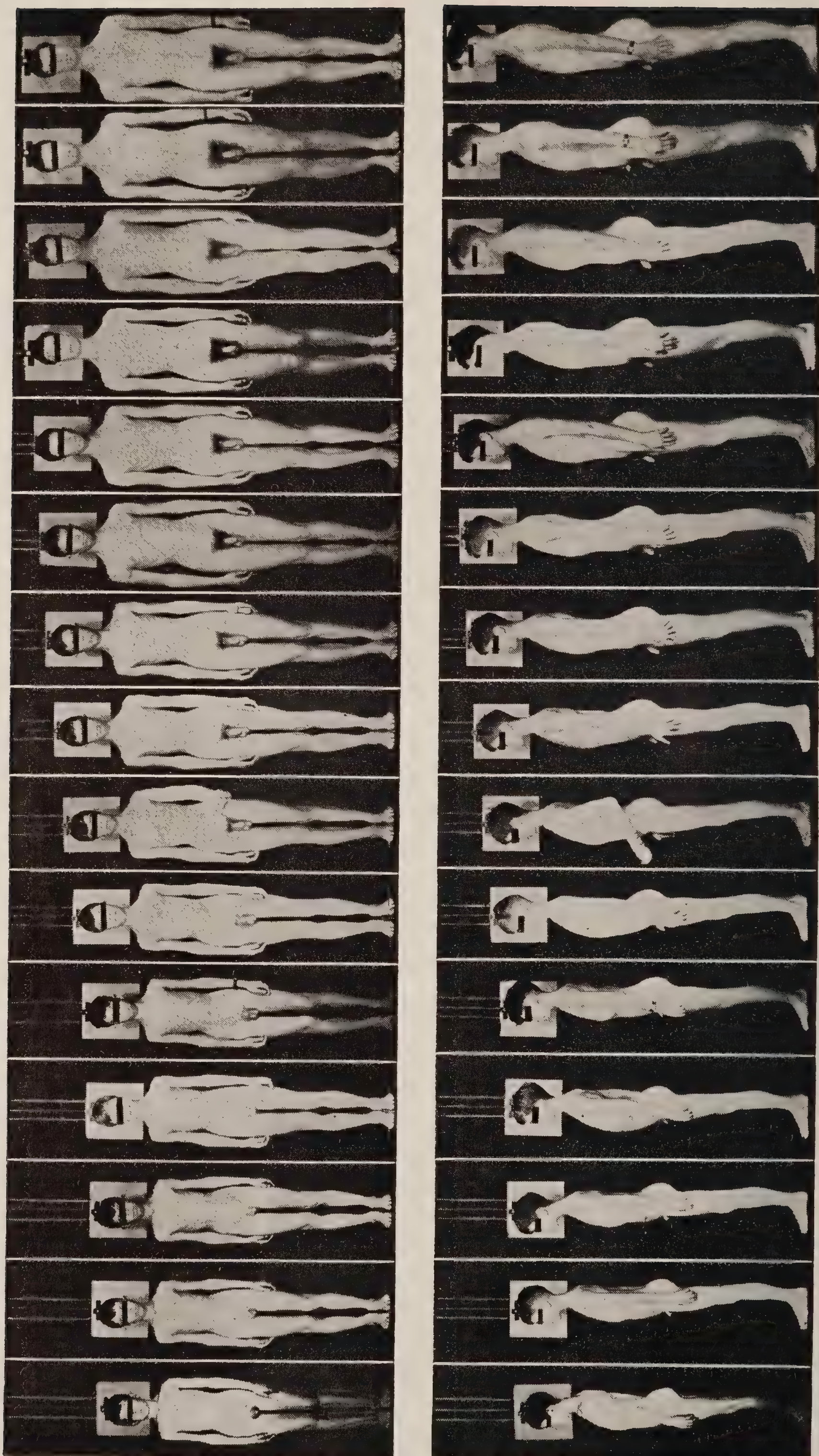
Section B THE SUBJECTS

NUMBER

The boys in the somatic study are the boys who were in the general Adolescent Study.[23] There were 112 boys who had the first examination; 56 boys who had the fifteenth examination. Fifty per cent of the boys remained in the study for the total period of seven years. Table 5 gives complete information regarding the number of cases included throughout the study. One of the reasons for the large number of terminations at the fourteenth and fifteenth examinations was the graduation from high school of the children in the advanced class.

If we consider the number of examinations which each case received, we find that 93 boys had six or more examinations, not always consecutive. (See Table 6.) These are the cases which are included in the analysis of somatic development. A more detailed account of the number of examinations which each boy received is given in Appendix E.

(Continued on page 42)



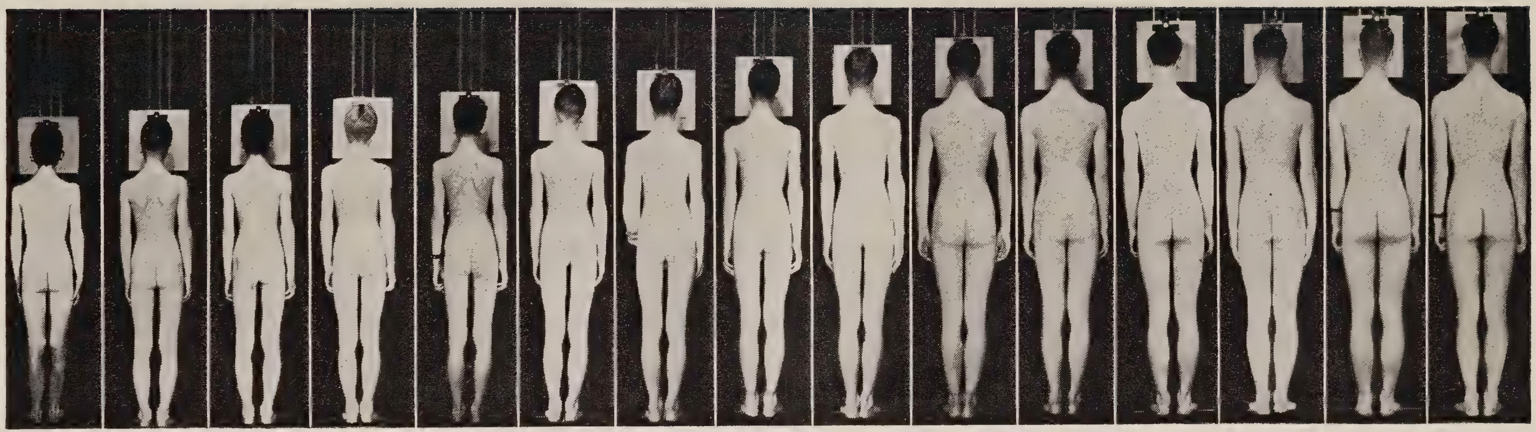


FIGURE 20. A complete series of photographs of one boy taken at six month intervals during the seven years of the study. Similar photographic series were available for each boy whose records were analyzed in this study. Such series seem essential for understanding individual differences in the process of human development as well as for the identification of the common sequences of developmental phenomena.

Table 5 CASES IN THE STUDY OF SOMATIC DEVELOPMENT

Examination Number	*Number Examined* Boys	*Number Absent* Boys	*Number Terminated* Boys	*Per cent Remaining in Study* Boys
1	112			
2	106	1	5	95.5
3	106		1	94.6
4	98		8	87.5
5	95		3	84.8
6	93		2	83.0
7	82		1	82.1
8	89	1	2	80.4
9	87	1	2	78.6
10	81	2	5	74.1
11	79	3	1	73.2
12	80	1	1	72.3
13	74	2	5	67.9
14	69		7	61.6
15	56		13	50.0

Table 6 MAXIMUM NUMBER SEMIANNUAL EXAMINATIONS FOR EACH CASE

Number of examinations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Number of boys	5	1	8	3	2	1	2	2	5	1	1	5	7	13	56	112

AGES

The study was planned to focus on growth during the second decade of life. The children were selected from the high and low fifth grades in order to secure as many ten year olds as possible.

An analysis of the 93 boys who had six or more physical examinations shows that on their first examination they ranged in age from 9.9 years to 12.8 years. The mean age was 11.05 years (S. D. .57 year). Seventy-five per cent of the cases around the median were between 10.3 years and 11.7 years. Table 7 and Figure 21 present the distribution of the boys by chronological age at the first examination.

Age in years	Case numbers
9.9	216, 82
10.0	134
10.1	184, 6
10.2	212, 136, 130, 110, 108
10.3	206, 158, 88
10.4	228, 144, 74
10.5	166, 116, 100
10.6	236, 230, 224, 220, 178, 176, 170, 164, 154, 120
10.7	242, 218, 180, 32, 12
10.8	250, 234, 114, 112, 52, 34, 18
10.9	232, 162, 146, 142, 118, 104, 64, 40, 38, 36, 30, 24
11.0	246, 172, 168, 150, 80, 68, 50
11.1	54, 140, 102, 84, 44, 26, 8
11.2	66
11.3	296, 106, 96, 92, 72, 4
11.4	190, 58
11.5	244, 90, 62, 60
11.6	86
11.7	10
11.8	56, 42
11.9	292, 188, 2
12.0	14
12.1	
12.2	
12.3	304, 300, 294
12.4	
12.5	
12.6	78
12.7	
12.8	302

FIGURE 21. Distribution of boys by age at first examination. Ninety-three boys by case numbers. Based on Table 7.

Table 7 AGE OF CHILDREN AT FIRST EXAMINATION

Chronological Age in Years	Number of Boys
9.9	2
10.0	1
10.1	2
10.2	5
10.3	3
10.4	3
10.5	3
10.6	10
10.7	5
10.8	7
10.9	12
11.0	7
11.1	7
11.2	1
11.3	6
11.4	2
11.5	4
11.6	1
11.7	1
11.8	2
11.9	3
12.0	1
12.1	0
12.2	0
12.3	3
12.4	0
12.5	0
12.6	1
12.7	0
12.8	1

SUMMARY

The study of somatic development of boys is based on data for 93 boys collected semiannually over a period of seven years. The boys ranged in age at the first examination from 9.9 years to 12.8 years, with a mean age of 11.05 years. The data include anthropometric measurements of length, breadth, depth, circumferences, tissue thickness, and strength; medical examinations; and photographs of front, side, and rear views taken under standard conditions.

FOOTNOTES FOR CHAPTER III

[1] Herbert R. Stolz, M.D., and Frank Sawyer, M.D.; Nathan Shock, Ph.D.

[2] See record form in Appendix A.

[3] It is important to take this into account when comparing the data from this study with other studies, such as the Harvard Growth Study where certain of the measurements were made over clothing.

[4] A tenth of a kilogram equals .22 pound or a little less than a quarter of a pound.

[5] Ten millimeters, or one centimeter, equal .3937 inch.

[6] Baldwin, Bird T.: Physical Growth of Children from Birth to Maturity. University of Iowa Studies in Child Welfare, Vol. 1, No. 1, 1921, Chap. 2.

[7] Approximately the nipple level in boys.

[8] The accuracy of the linen tape was checked monthly against a metal standard. When the tape showed any evidence of stretch, it was discarded.

[9] Franzen, R.: Physical Measures of Growth and Nutrition, No. II, School Health Research Monographs, American Child Health Association, New York, 1929, pp. 108*ff*.

[10] Collins dynamometer for hand grip.

[11] Collins dynamometer for measuring shoulder pull.

[12] Collins dynamometer for measuring shoulder thrust.

[13] The study of reliability of both anthropometric measurements and ratings on medical examination was made by Dr. Caroline Tryon.

[14] Height, sitting height, stem length, biacromial breadth, bi-iliac width, arm, thigh, and leg circumference.

[15] Forms used for recording the medical examination will be found in Appendix A.

[16] The photographs of the children show in some cases better posture than the examiner observed during the examination, but the nature of the setup for taking the photographs caused the children to stand in better posture than usual.

[17] Graves, W. W.: "Scapular Types in the Living." *Arch. Int. Med.,* **36**:51–61, 1925.

[18] The rating scale on hair used in this study was adapted by H. R. Stolz from a scale suggested by Charles B. Davenport. See *Guide to Physical Anthropometry and Anthroposcopy*. Eugenics Research Association Handbook Series, Cold Spring Harbor, New York, 1927.

[19] The personality scale used at the physical examination is reproduced in Appendix B.

[20] The camera contained a Taylor Hobson Cooke process apochromatic lens, series IX, with thirteen inch equivalent focus, fitted with a Compur shutter. It was purchased from the Eastman Kodak Company.

[21] See Chapter II for description of sample.

[22] See Appendix C for list of all cases with the date of initial examinations.

[23] See description in Chapter II.

Chapter IV THE PERIOD OF PUBERAL GROWTH IN HEIGHT

IN describing the phenomena of human growth it has been the usual practice to present growth achieved at successive chronological ages. Time elapsed since birth in days, months, and years can be readily established with a high degree of reliability. There is a general correspondence between years lived and development attained. Our laws and institutions are based upon the assumption of this expectancy.

Many investigators of somatic growth have pointed out that for appraising the development of an individual other data besides chronological age are necessary. Bone age, determined by X-ray appraisal, has been suggested as a better measure of maturity and as a better reference scale for appraising other aspects of development. For application to adolescent development Shuttleworth [1] has advocated that the occurrence of the maximum increment in growth be used as the primary point of reference.

In this study we are presenting patterns of somatic growth for individuals from a sample of boys on whom data were collected longitudinally over a seven year period during adolescence. The patterns are described in terms of rate or velocity of growth, in timing relation to a specified puberal growth period for height for each individual. Thus the onset, midpoint, and end of the puberal growth period in height become the developmental points to which the other growth phenomena are related.

This method of presentation does not imply that we believe the velocity changes in height growth provide adequate data for charting the stages of development of the body as a whole. Indeed, we shall point out many differences in timing. We are convinced, however, that the changes in height growth during adolescence are so sequentially related to other aspects of somatic development that they constitute a useful reference scale in any attempt to describe the process of such development.

DEFINITION OF THE PUBERAL GROWTH PERIOD FOR HEIGHT

The rate of growth (which is used as the basis for analysis of the data in this study) has been calculated on the basis of the average gain an

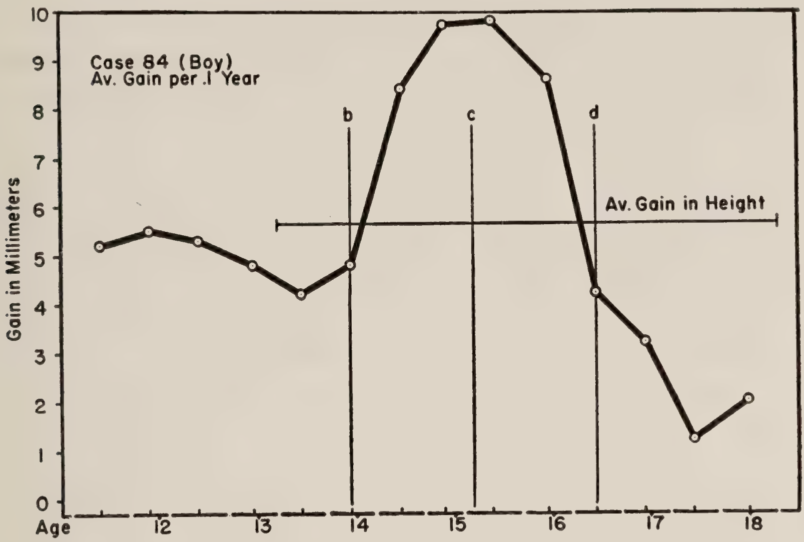


FIGURE 22. Illustrating the method used in designating the puberal growth period in height. The horizontal line marked "Av. Gain in Height" represents the average gain per .1 year for the length of time indicated by the length of the line (eleven examinations over a five year period, of which the apex is the center). Line *b* is drawn through the first point on the curve which falls below the average to the left of the apex; Line *d* through the first point which falls below the average to the right of the apex. The period *b–d* is designated the period of puberal growth in height. Point *b* is the onset and Point *d* is the end of the puberal growth period for height. Line *c* is drawn at the mid-point between *b* and *d* for purposes of reference in describing the two halves of the period.

individual made per tenth of a year. This was done because although the examinations were planned every half year, there were many irregularities in the actual schedule as it worked out.[2] Therefore, the actual time between examinations was calculated to the nearest tenth of a year. The gain between any two examinations was divided by the actual interval in tenths of years. This average gain per tenth of a year is indicated on the charts at the mid-point between examinations.

The period of maximum growth in height which we have designated as the *puberal growth period for height* was determined in the following way. Beginning with the examination which marked the end of the greatest gain in height (designated the apex for height growth), five examinations were counted on each side of this point. The average gain per tenth of a year made between the first and the last of these ten examinations was calculated. At the first point on the curve to the left of the apex which fell below the average gain a perpendicular line b was drawn. Similarly Line d was

drawn to the right of the apex at the first point which fell below the average gain. The period between b and d has been designated as the puberal growth period for height. Figure 22 illustrates the technique used.

CASES STUDIED

There were 67 boys whose records made possible an analysis of the puberal growth period for height. These 67 boys are used as the intensive sample for analysis throughout this study. In addition there were data available on certain aspects of the study for 20 other boys in the Adolescent Study and for 21 boys in another longitudinal study.[3]

TIMING OF THE PUBERAL GROWTH PERIOD FOR HEIGHT

Onset of puberal growth period for height. The differences in timing of development are clearly shown by the wide range in ages of different boys at the onset of their puberal growth period for height. Figure 23 gives the complete distribution of 67 boys according to age at onset.[4]

Age in years	10.50	10.75	11.00	11.25	11.50	11.75	12.00	12.25	12.50	12.75	13.00	13.25	13.50	13.75	14.00	14.25	14.50	14.75	15.00
								170											
								2											
								44											
								110											
								176	*228*										
								100	*6*										
								230	*12*		*296*								
								154	212		*162*			236					
							4	120	64	*178*	*142*			218					
						104	146	8	136	54	304	224		84					
				140		242	72	184	112	10	292	134		220	190				
				26		164	108	80	60	62	294	68	66	78	24				
				150	*118*	86	88	168	96	166	234	244	106	50	52				
	74	216	82	144	250	18	32	116	180	40	206	58	92	30	34	36	130	*90*	*158*

FIGURE 23. Distribution of 81 boys by case numbers according to age in years at the onset of their puberal growth period in height (supplementary cases in italics). For the 67 cases: mean, 12.76 years; standard deviation, .92 year; median, 12.65 years; Q_1, 12.14 years; Q_3, 13.52 years. For 81 cases: mean, 12.78 years; standard deviation, .91 years; median, 12.66 years; Q_1, 12.25 years; Q_3, 13.39 years.

Case 74 was the earliest developer by this criterion, being 10.70 years old at the onset; whereas Case 130, the latest developer, was almost four years older, 14.65 years of age when he began his puberal growth period. the mean age for the group was 12.76 years with a standard deviation of 1.92 years. The median was 12.65 years, fifty per cent of the cases being between 12.14 years and 13.52 years.

We have evidence that the range for age at onset is even wider than our sample indicates. Data for this point were available for 14 additional cases from the Adolescent Study and 21 cases from another study.[5] The addition of these 35 cases (making a total of 102 cases) gave a mean age at onset of 12.80 years, almost the same as for the sample of 67 cases. But there were four boys in this supplementary group who were older at the onset of the puberal growth period for height than any in our intensive sample. These boys were respectively 14.75, 15.15, 15.25, and 15.75 years of age at onset.

In Table 8 a comparison of the different samples of boys according to age at onset is given. The intensive sample of 67 boys is almost identical with the sample of 102 boys in all measures except the range and sigma.

Table 8 COMPARISONS OF AGE AT ONSET OF PUBERAL GROWTH PERIOD FOR HEIGHT OF DIFFERENT SAMPLES OF BOYS

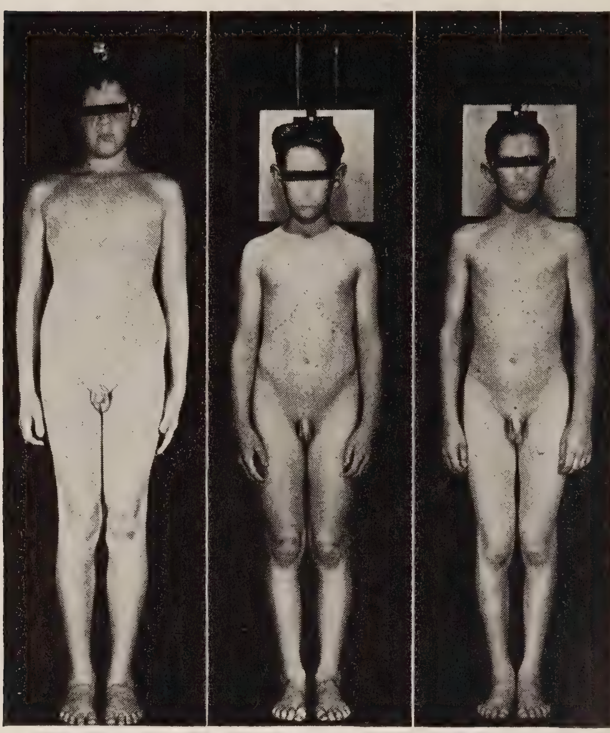
	Chronological Age in Years at Onset		
	Intensive Sample 67 cases	Adolescent Study 81 cases*	All Available 102 cases*
Range	10.70–14.65	10.40–14.75	10.40–15.75
Mean	12.76	12.78	12.80
Standard deviation	.92	.91	1.03
Median	12.65	12.66	12.66
Q_1	12.14	12.25	12.12
Q_3	13.52	13.39	13.57

* Includes the 67 cases in intensive sample.

Figure 24 presents photographs of five boys (Cases 74, 18, 64, 30, and 130) at the onset of the puberal growth period for height, illustrating differences in chronological age at this time in development.

End of puberal growth period for height. The boys in the intensive sample completed their puberal growth period in height at ages varying from 14.20 years (Cases 74 and 146) to 17.50 years (Case 130). This was a range of 3.3 years—somewhat less than the variation in age at onset. Figure 25 gives the distribution of the boys according to age at the end of the period.

The mean age for the intensive group was 15.57 years with a standard deviation of .87. It will be noted that this deviation is slightly less than the deviation of the group at onset. The median age was 15.52 years, fifty per cent of the cases being between 14.88 years and 16.26 years. This indicates a clustering around the median similar to onset.



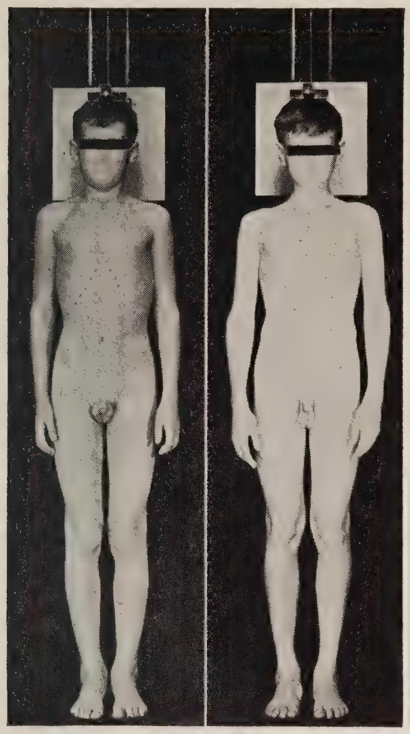
Case 74	Case 18	Case 64
C.A. 10.70	11.75	12.70

FIGURE 24. Age at onset

Age in years	13.00	13.25	13.50	13.75	14.00	14.25	14.50	14.75	15.00	15.25	15.50	15.75	16.00	16.25	16.50	16.75	17.00	17.25	17.50
								170											
								56											
								14											
							4	112											
							2	86	*302*										
							26	120	72		66		*162*						
					300		144	150	292		212	230	*6*			78			
					232		108	154	60		164	236	234		294	220			
					42		242	44	32	18	92	54	206	84	244	190			
		140			216	*172*	88	80	96	8	136	168	24	58	52	68			
		118			146	104	110	176	304	184	106	10	224	50	34	36			
	114	*102*			74	250	82	116	100	40	134	64	62	166	180	30	218		130

FIGURE 25. Distribution of 83 boys by case numbers according to age in years at the end of their puberal growth period in height (supplementary cases in italics). For the 67 cases: mean, 15.57 years; standard deviation, .87 years; median, 15.52 years; Q_1, 14.88 years; Q_3, 16.26 years. For 83 cases: mean, 15.35 years; standard deviation, .97 year; median, 15.23 years; Q_1, 14.66 years; Q_3, 16.09 years.

We have data from 34 cases to supplement the intensive sample of 67 cases on the timing of the end of the puberal growth period for height. Among these cases there were 9 who reached the end of the period earlier than 14.20 years which was the lowest age in the range of the 67 cases.



Case 30 **Case 130**

C.A. 13.75 14.65

Age at onset

FIGURE 24. Photographs of five boys at *onset* of their puberal growth period for height, illustrating differences in chronological age at this point in development. Case 64 is about at the median for the group of 67 cases.

The range for the 101 cases (67 + 34 supplementary) was from 13.10 years to 17.50 years. These cases also lowered the mean by a quarter of a year (from 15.57 years to 15.33 years).

In Table 9 are given comparable figures regarding the ages of the different samples of boys at time of completion of puberal growth period for height.

Table 9 COMPARISON OF THE AGES OF DIFFERENT SAMPLES OF BOYS AT THE END OF THE PUBERAL GROWTH PERIOD FOR HEIGHT

	Chronological Age in Years at End		
	Intensive Sample 67 cases	Adolescent Study 83 cases*	All Available 101 cases*
Range	14.20–17.50	13.10–17.50	13.10–17.50
Mean	15.57	15.35	15.33
Standard deviation	.87	.97	.93
Median	15.52	15.23	15.19
Q_1	14.88	14.66	14.75
Q_3	16.26	16.09	16.04

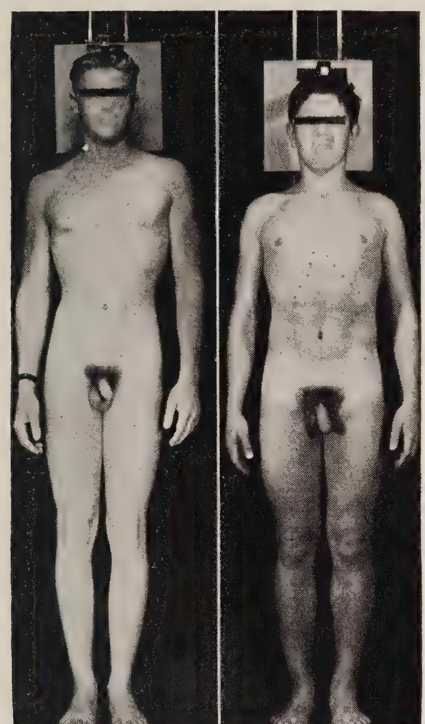
* Includes the 67 cases in intensive sample.

Case 104 **Case 250** **Case 134**
C.A. 14.25 14.45 15.50
Age at end

Figure 26 presents photographs of five boys (Cases 104, 250, 134, 166, and 218) illustrating various chronological ages at this point in development.

Timing of apex of height growth. The age at which the boys reached the apex velocity of their growth in height gives a further confirmation of the wide variation in timing. Figure 27 gives the distribution of the 67 boys plus 20 supplementary cases according to age at the puberal apex for height growth.

The range for the intensive sample was from 12.25 years (Case 74) to 15.70 years (Case 30). The mean age was 14.10 years with a standard deviation of .90 year. The median age was 14.04 years. Fifty per cent of the cases were between 13.40 years and 14.90 years. The slightly wider variation in timing of the apex in velocity for height over either onset or end for these boys, as shown by the quartile distribution, emphasizes the fact that the growth velocity curves for height are not all symmetrical. In some cases the apex may occur near the onset, in some near the middle, and in some near the end of the puberal growth period.



Case 166 **Case 218**
C.A. 16.30 17.00
Age at end

FIGURE 26. Photographs of five boys at the *end* of their puberal growth period for height, illustrating differences in chronological age at this point in development. Case 134 is at the median for the group of 67 boys.

In addition to the data from the 67 cases used for intensive analysis of the puberal growth period of height, there were available data from 20 cases in the Adolescent Study and 16 cases from another study.

Four of these 36 cases had their apex of velocity in height growth earlier

Age in years	*11.75*	*12.00*	12.25	12.50	12.75	13.00	13.25	13.50	13.75	14.00	14.25	14.50	14.75	15.00	15.25	15.50	15.75	16.00	16.25	16.50
									228											
									120	*302*										
					170				134	*6*										
					2	*300*	*14*		82	304					220					
					104	*56*	212		184	66	62			294	84					
					250	*12*	86	*42*	168	60	236			234	78					
				172	100	*4*	230	292	166	106	68			52	36	30				
		232		146	176	26	144	32	80	72	10	64	*162*	244	190	34				
		118	*140*	216	154	112	116	242	8	206	50	136	224	180	58	218				
	102	*114*	74	88	150	108	44	96	18	110	40	164	54	92	24	130			*90*	*158*

FIGURE 27. Distribution of 87 boys by case numbers according to age in years at the *apex* of their puberal growth period in height. For the 67 cases: mean, 14.10 years; standard deviation, .90 year; median, 14.04 years; Q_1, 13.40 years; Q_3, 14.90 years. Italics indicate the 20 cases added to the sample of 67 cases.

than any case in the sample of 67 cases; 5 cases had the apex later than any in the original sample. Thus the range was increased, extending from 11.90 years to 16.65 years. For 24 of these boys the apex occurred preceding the mean for the 67 boys; 2 occurred at the mean and 10 after the mean. Therefore the mean for the total 103 cases was lowered to 13.99 years, as contrasted with 14.10 years for the 67 cases.

The position of the height apex was compared with the mid-point of the puberal growth period. This mid-point is indicated by Line c on the charts. Figure 28 shows the relation of the height apex to the mid-point of each individual curve.[6]

									26										
					190				220		80								
230		112			108				184		294		54						
100		212	66		116				24		224		64						
176		206	92		96				32		40		136						
88	166	292	146		52		250		304	84	34	242	58	234					
50	154	236	130		44	168	86	104	78	244	216	120	30	180					82
68	66	134	106	150	36	74	10	62	8	218	18	60	144	110		164			72
.8	.7	.6	.5	.4	.3	.2	.1	0	1.	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.10

Years from mid-point

Preceding *Following*

FIGURE 28. Distribution of 67 boys by case numbers according to the timing of the apex of height growth in relation to the mid-point of the puberal growth period in height.

Table 10 RELATION OF HEIGHT GROWTH APEX OF 67 BOYS TO THE MID-POINT OF THE PUBERAL GROWTH PERIOD FOR HEIGHT

	Number of Cases	*Per Cent*	*Range* Years
Height apex at mid-point	2	2.98	
Height apex preceding mid-point	32	47.76	.05– .80
Within .5 year prior to mid-point	18	26.86	.05– .5
Between .5 year and .8 year prior to mid-point	14	20.89	.53– .80
More than .8 year prior to mid-point	0		
Height apex following mid-point	33	49.25	.02–1.05
Within .5 year following mid-point	27	40.40	.02– .50
Between .5 year and .8 year following mid-point	4	5.97	.52– .77
More than .8 year following mid-point	2	2.98	1.02–1.05
Height apex within + or – .5 year of mid-point	47	70.15	.50– .47

In only two cases of the 67 boys (Case 62 and Case 104) did the apex of height occur precisely at the middle of the puberal growth period, but three other cases occurred at .02 year following the mid-point, which can

Table 11 AGE AT CORRESPONDING POINTS OF PUBERAL GROWTH IN HEIGHT—67 BOYS

Age in Years	*Onset*			*Apex*			*End*		
	Number of Cases	Cumulative Number of Cases	Cumulative Per Cent	Number of Cases	Cumulative Number of Cases	Cumulative Per Cent	Number of Cases	Cumulative Number of Cases	Cumulative Per Cent
10.50	1	1	1.49						
10.75	1	2	2.98						
11.00	1	3	4.48						
11.25	3	6	8.95						
11.50	1	7	10.45						
11.75	5	12	17.90						
12.00	5	17	25.37						
12.25	12	29	43.28	1	1	1.49			
12.50	7	36	53.73	3	4	5.97			
12.75	5	41	61.13	7	11	16.42			
13.00	5	46	68.66	3	14	20.89			
13.25	5	51	76.05	6	20	29.85			
13.50	3	54	80.60	4	24	35.82			
13.75	7	61	90.98	9	33	49.25	1	1	1.49
14.00	4	65	97.01	7	40	59.70	3	4	5.97
14.25	1	66	98.51	6	46	68.66	1	5	7.46
14.50	1	67	100.00	3	49	73.13	7	12	17.90
14.75				1	50	74.63	9	21	31.34
15.00				6	56	83.58	7	28	41.79
15.25				7	63	94.03	4	32	47.76
15.50				4	67	100.00	7	39	58.21
15.75							6	45	67.16
16.00							5	50	74.63
16.25							4	54	80.60
16.50							5	59	88.06
16.75							6	65	97.01
17.00							1	66	98.51
17.25							0	66	98.51
17.50							1	67	100.00

be considered as practically simultaneous (Cases 8, 78, and 304). The range for the 67 cases was from .80 year preceding the mid-point to 1.05 years following. The cases were almost evenly divided, 32 having the apex prior to the mid-point and 33 having the apex following the mid-point. There were 47 cases (70.15 per cent) with the apex within .5 of a year of the mid-point. Between .55 year prior to the mid-point and .52 year after there were 55 cases (80.60 per cent), which indicated a decided tendency for the apex for height to occur within six months of the mid-point of the puberal growth period.

Figure 29 presents the height growth curves of four boys (Cases 154, 44, 32, and 120) in which the mid-point of the puberal growth period fell at age 13.6 years. Figure 30a presents curves of three boys selected as examples of the apex at the center of the puberal growth period (Case 62), early in the period (Case 230), and late (Case 82). Photographs of these three boys during the puberal growth period in height are shown in Figure 30b.

(*Continued on page 60*)

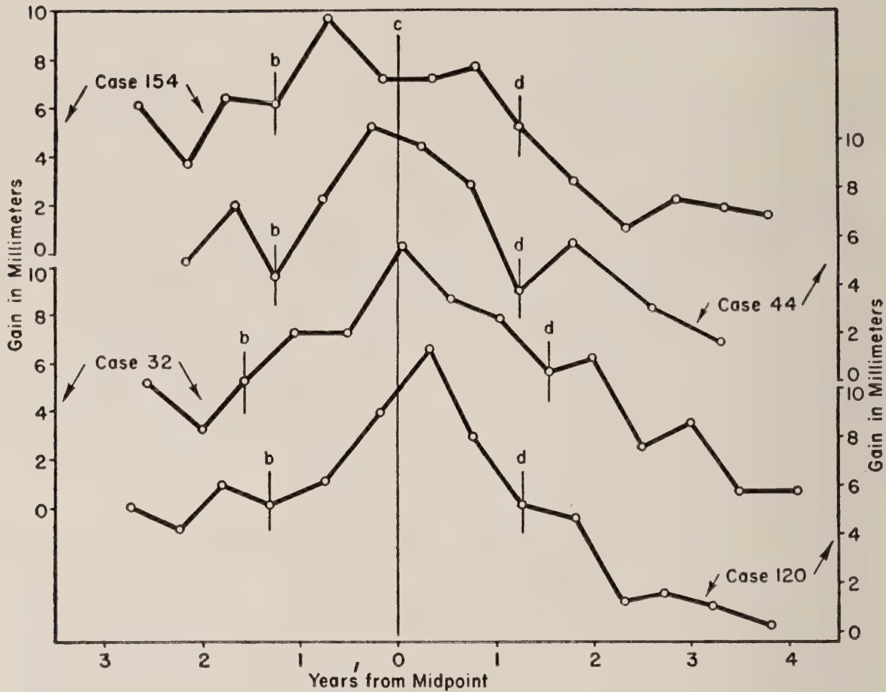


FIGURE 29. Height growth curves of four boys (Cases 154, 44, 32, and 120) selected as examples of variation in timing of the apex velocity of growth in height. The mid-point of the duration of puberal growth period in height (c) is matched for each case (age 13.6 years). Figures on base line indicate the number of years from mid-point c.

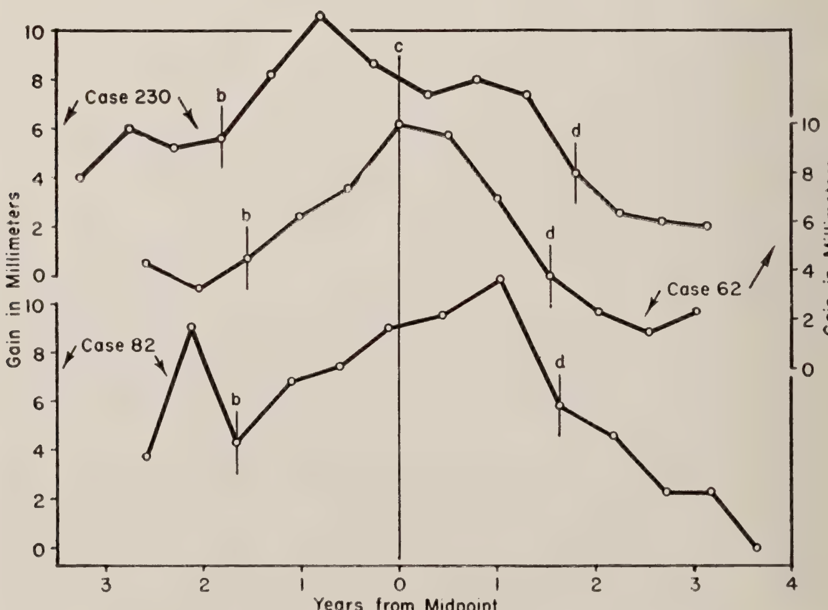
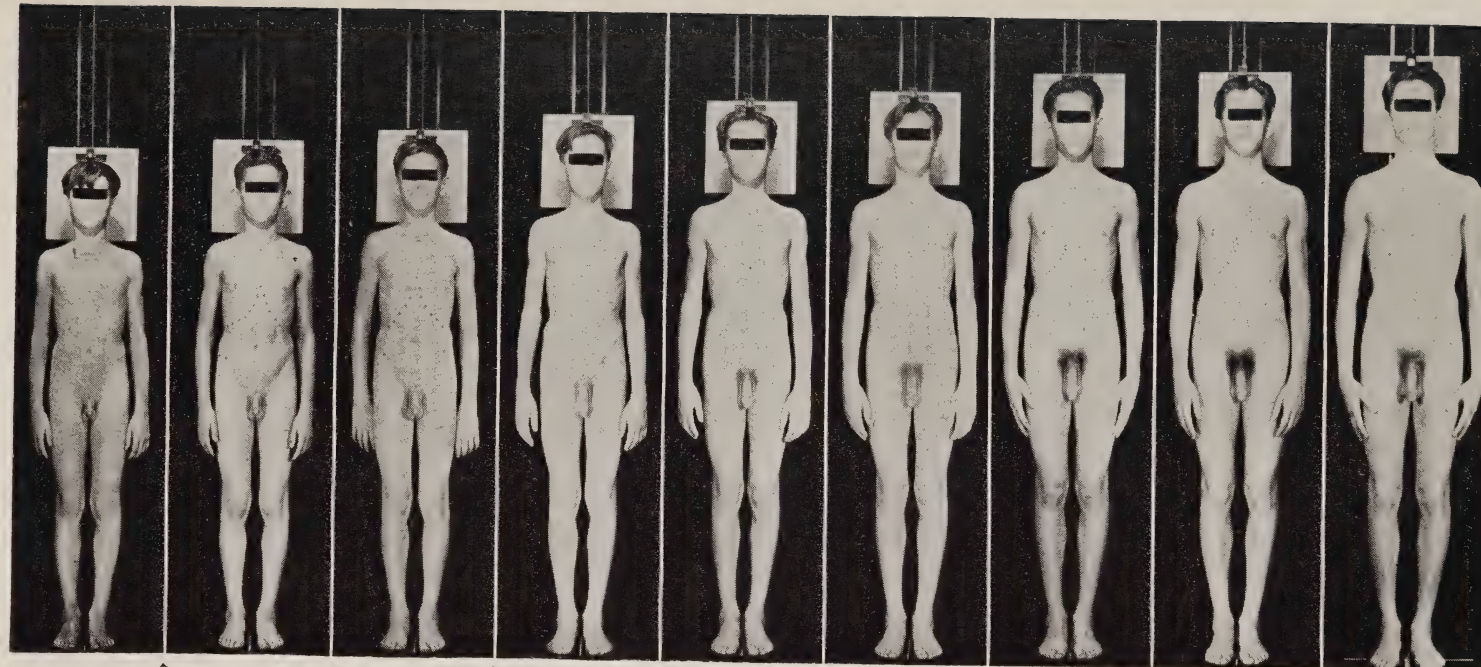


FIGURE 30a. Height growth curves for three boys illustrating apex for height growth early in the puberal period (Case 230), at the mid-point of the period (Case 62), and late in the period (Case 82). These boys were of different ages at the mid-point, which is indicated by Line *c*.

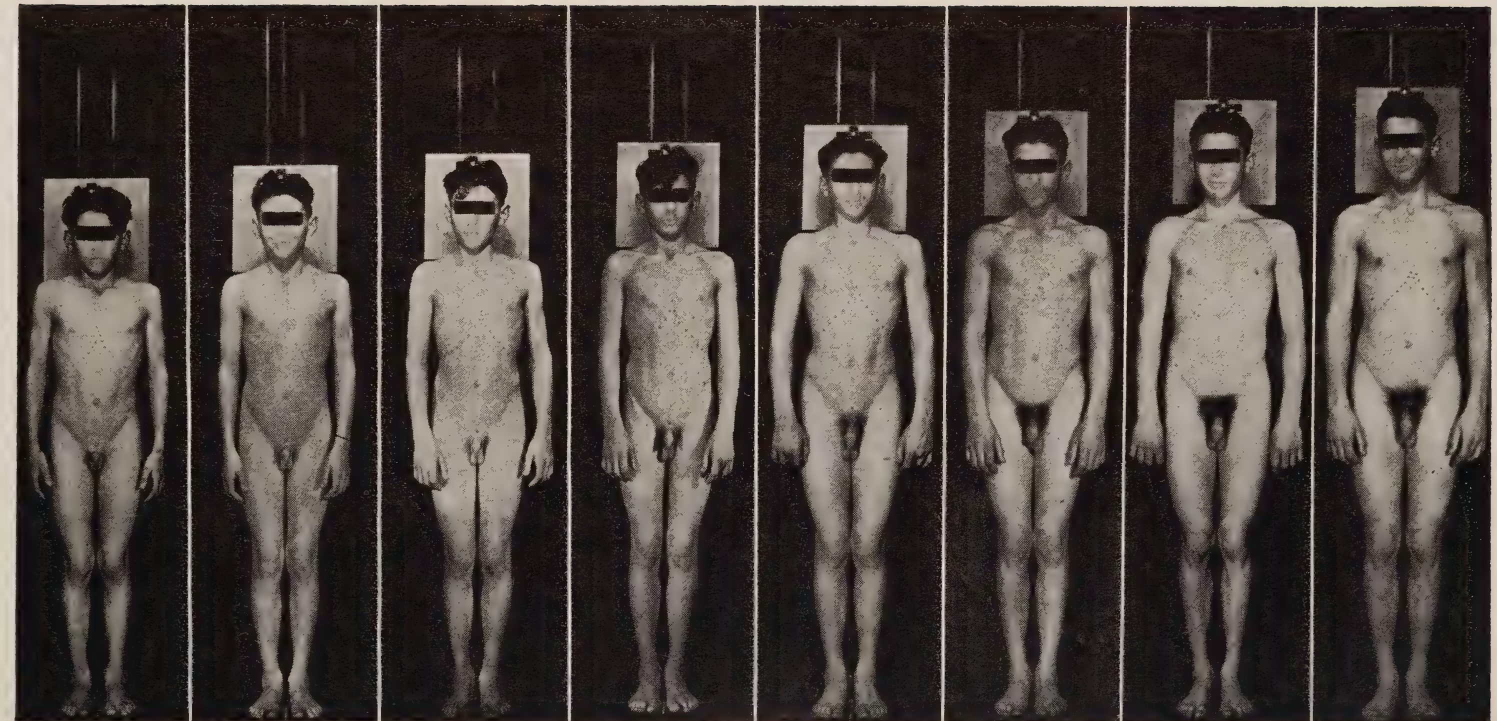


C.A. 12.35 Onset

Apex

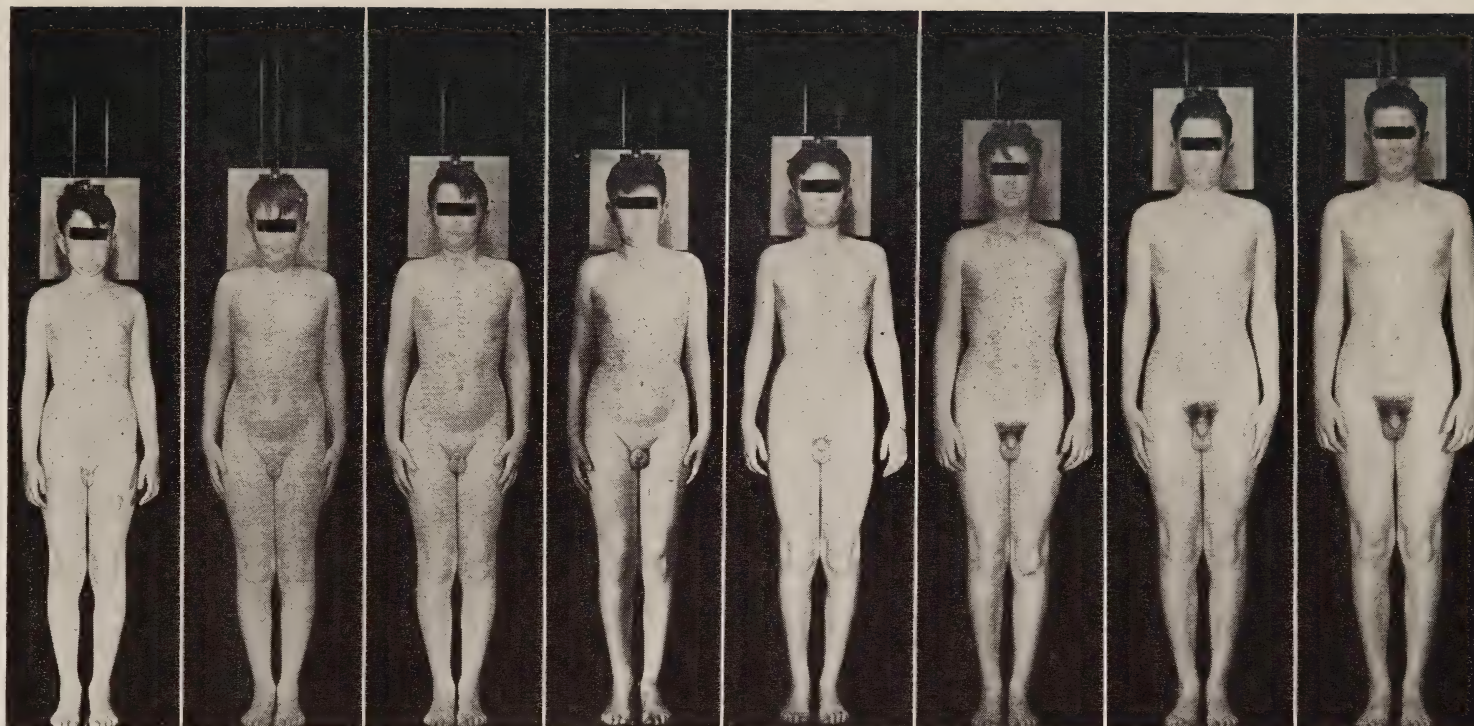
15.95 End

FIGURE 30b. **Case 230**



C.A. 12.9 Onset — Apex — 16.0 End

FIGURE 30b. **Case 62**



C.A. ↑ 11.2 ↑ 14.5

Onset Apex End

Case 82

FIGURE 30b. Photographs of the three boys during the puberal growth period of height. (See growth curves in Figure 30a.) The three cases vary in the time when the apex in height growth occurred. Case 230 had his apex early in the period, Case 62 at the middle, and Case 82 near the end of the period.

Relations of timing. Table 11, on Page 55, brings out some interesting relations in the timing of the various phases of this period of growth. Before half of the boys had entered the puberal growth period, some of the others had reached their apex of growth in height. Between 13.75 years and 14.75 years there was an overlapping, some boys completing their maximum growth, some at the apex, and some just beginning. At the age when the last boy had started on his maximum growth, 49 boys, or 73.13 per cent, had reached the apex and 12 boys, or 17.90 per cent of the cases, had completed their puberal growth period.

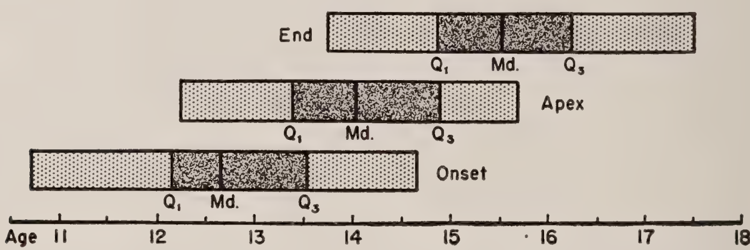


FIGURE 31. Range, median, and quartile range of ages in years of 67 boys at onset, apex, and end of puberal growth in height. Compare with Table 11.

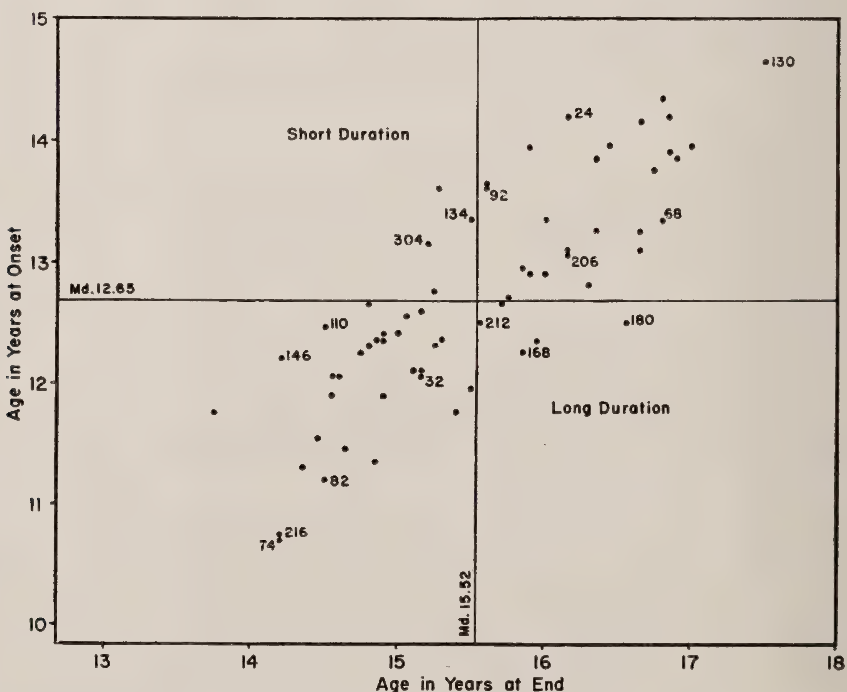


FIGURE 32. Relation of age at onset and age at end of puberal growth period in height for 67 boys. The numbers refer to specific boys by case numbers (r .814, P.E. $\pm$ .028).

The overlapping of the ages at which boys started the puberal growth period in height, reached the apex, and finished the period is shown graphically in Figure 31.

Relation of timing of onset and end. There was a high coefficient of correlation between the age when a boy began his puberal growth period in height and the age when he completed that period (Pearson r. .814, P.E. .028). This can be seen graphically in the scatter diagram in Figure 32. On the whole, the boys who began early completed the period early; the ones who started late were among the last to reach the end.

Figure 33a shows the difference in time of development between two cases, one precocious and one retarded. It will be noted that while Case 216 started on his puberal growth period at 10.75 years and completed it at 14.20 years, Case 130 did not start until 14.65 years and continued until 17.50 years.[7] These boys are shown in Figure 33b.

There were five groups of boys who began the puberal growth period in height at about the same age, but who differed greatly in the age at which the period of maximum growth in height was completed (Table 12).

The curves and photographs of two of these boys (Cases 168 and 146) are presented in Figures 34a and b.

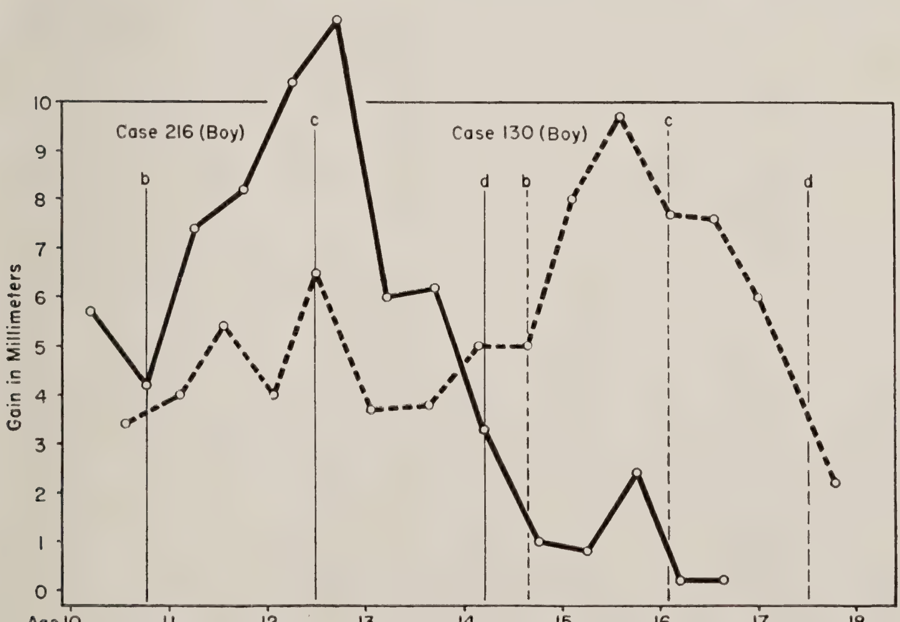
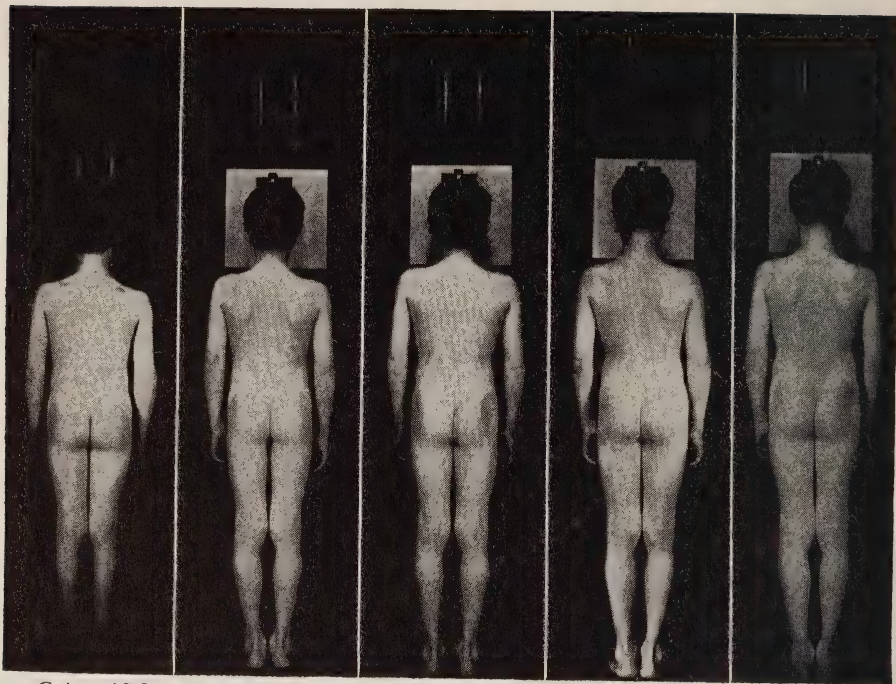
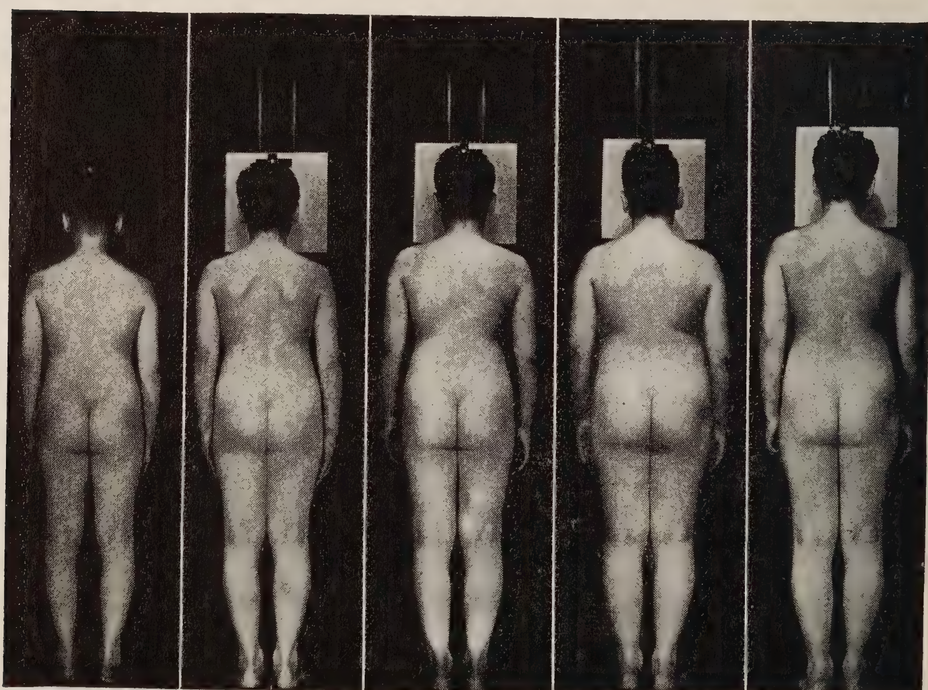


FIGURE 33a. Height growth curves for two boys (Cases 216 and 130) illustrating early and late development. Case 216 was one of the most precocious in beginning and ending the puberal growth period. Case 130 was the latest among the 67 cases.



C.A. 10.2 10.9 11.3 11.8 12.3

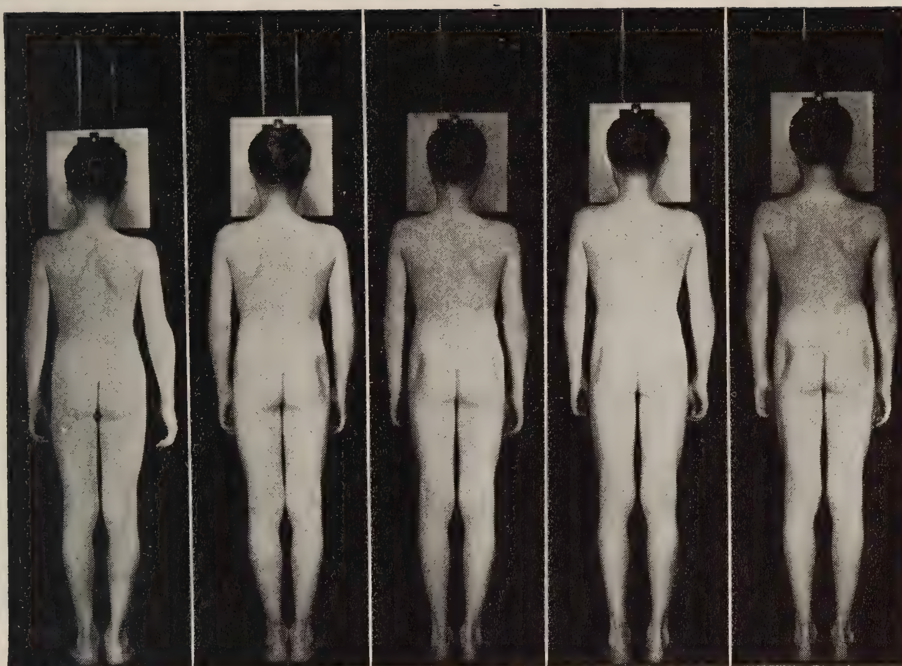
FIGURE 33b. **Case 130**



C.A. 9.9 10.5 ↑ 11.0 11.5 12.0

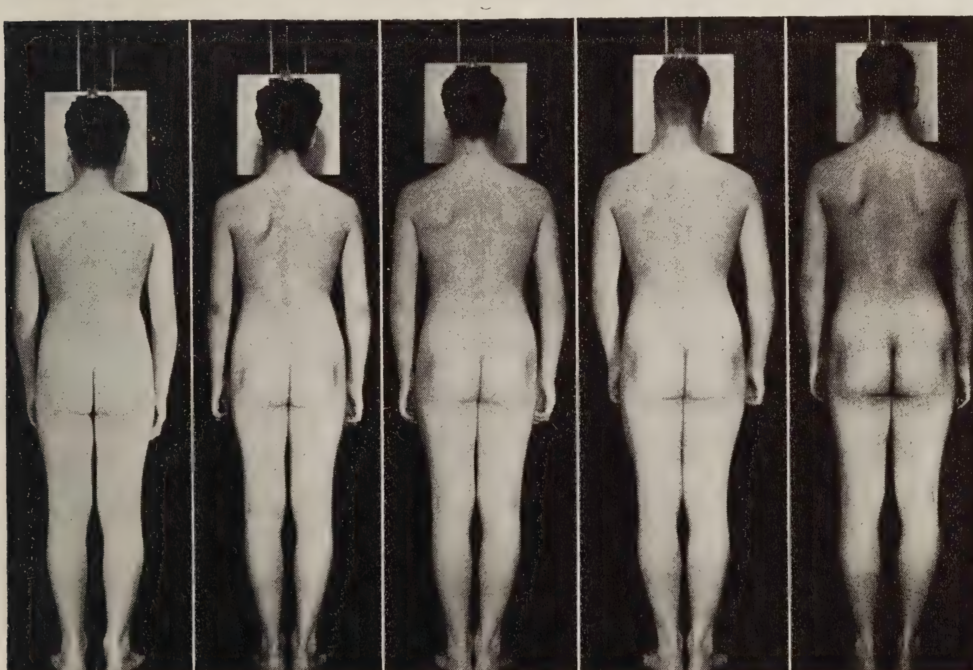
Onset

FIGURE 33b. **Case 216**



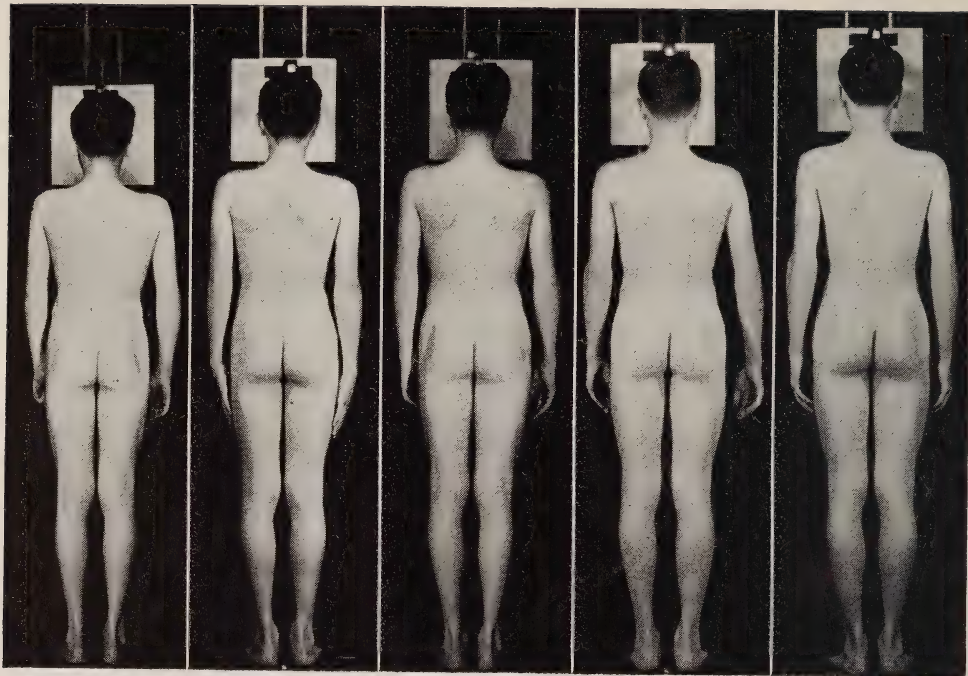
C.A. 12.7 13.4 13.9 14.4 ↑ 14.9
Onset

FIGURE 33b. **Case 130**



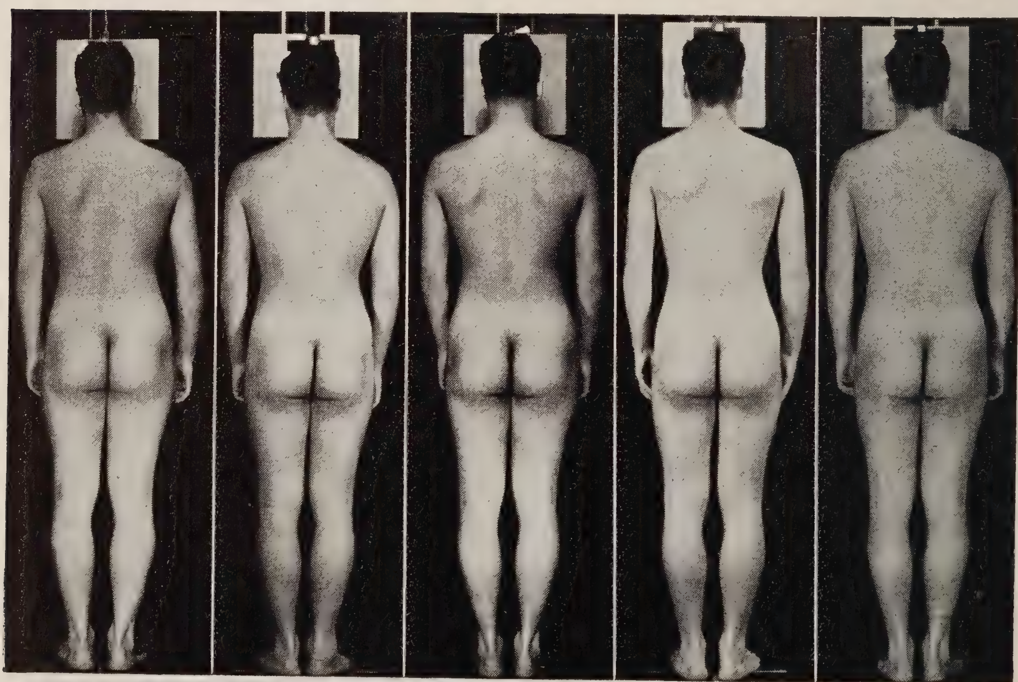
C.A. 12.5 12.9 13.5 13.9 ↑ 14.5
End

FIGURE 33b. **Case 216**



C.A. 15.3 15.8 16.3 16.8 17.2 ↑ End

FIGURE 33b. **Case 130**



C.A. 15.0 15.5 16.0 16.4 16.9

Case 216

FIGURE 33b. Complete series of photographs of two boys, one precocious (Case 216) and one retarded (Case 130) in growth in height. (See growth curves in Figure 33a.)

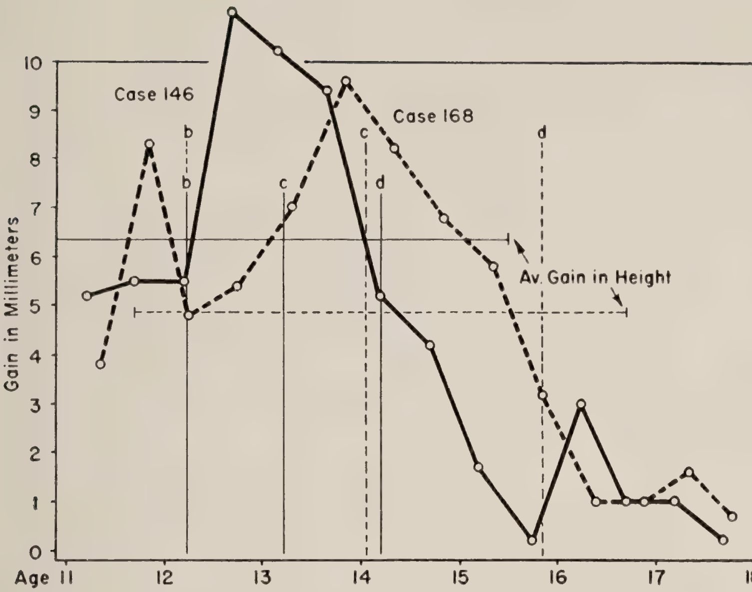
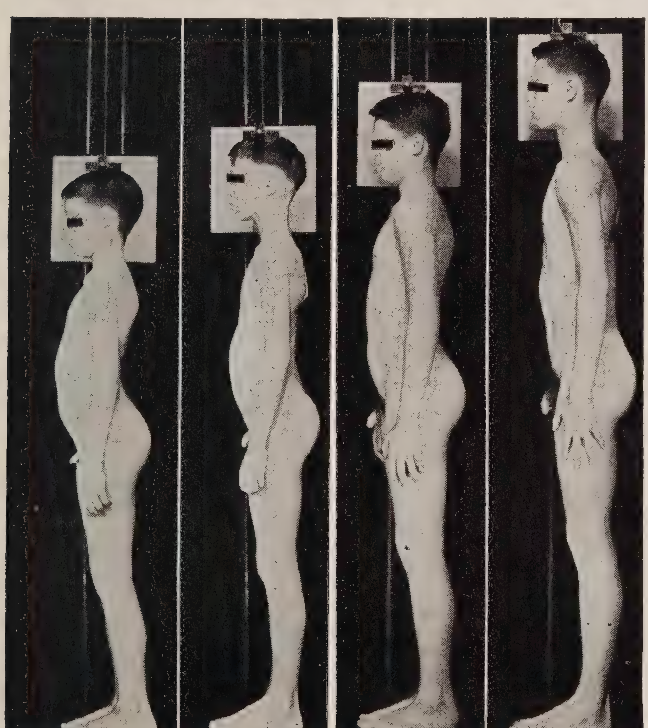


FIGURE 34a. Height curves of two boys (Cases 168 and 146) who began their maximum growth periods in height at the same age but ended it 1.65 years apart.



Case 146	Case 168	Case 146	Case 168
C.A. 12.20	12.25	14.20	15.85

Onset puberal height growth — End puberal height growth

FIGURE 34b. Photographs of the two boys whose height growth curves are presented in Figure 34a. These boys began the puberal growth period in height at the same age, but Case 168 took 1.65 years longer than than Case 146 to complete the period.

Table 12 CASES WITH SIMILAR ONSET AGE BUT DIFFERENT END AGE

Case	*Onset Age*	*End Age*
242	11.90	14.55
86	11.90	14.90
164	11.95	15.50
110	12.45	14.50
212	12.50	15.55
180	12.50	16.55
134	13.35	15.50
68	13.35	16.80
146	12.20	14.20
168	12.25	15.85
104	11.75	13.75
18	11.75	15.40

There were five pairs of cases where the boys were the same age at completion of the puberal growth period in height, but who began the period at different ages (Table 13).

Table 13 CASES WITH SIMILAR END AGE

Case	*Onset Age*	*End Age*
74	10.70	14.20
146	12.20	14.20
82	11.20	14.50
110	12.45	14.50
32	12.05	15.15
304	13.10	15.15
212	12.50	15.55
92	13.60	15.60
206	13.05	16.15
24	14.20	16.15

The height growth curves and photographs of two of these boys (Cases 304 and 32) are presented in Figures 35a and b.

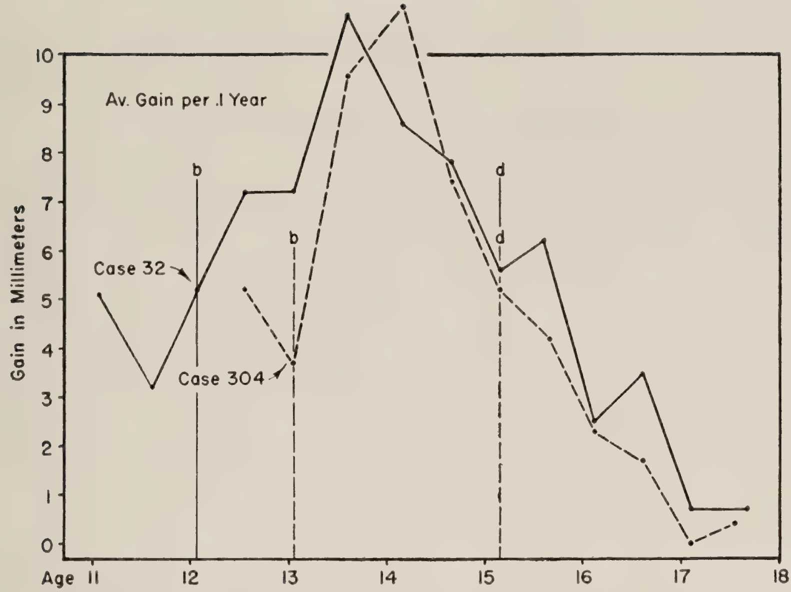
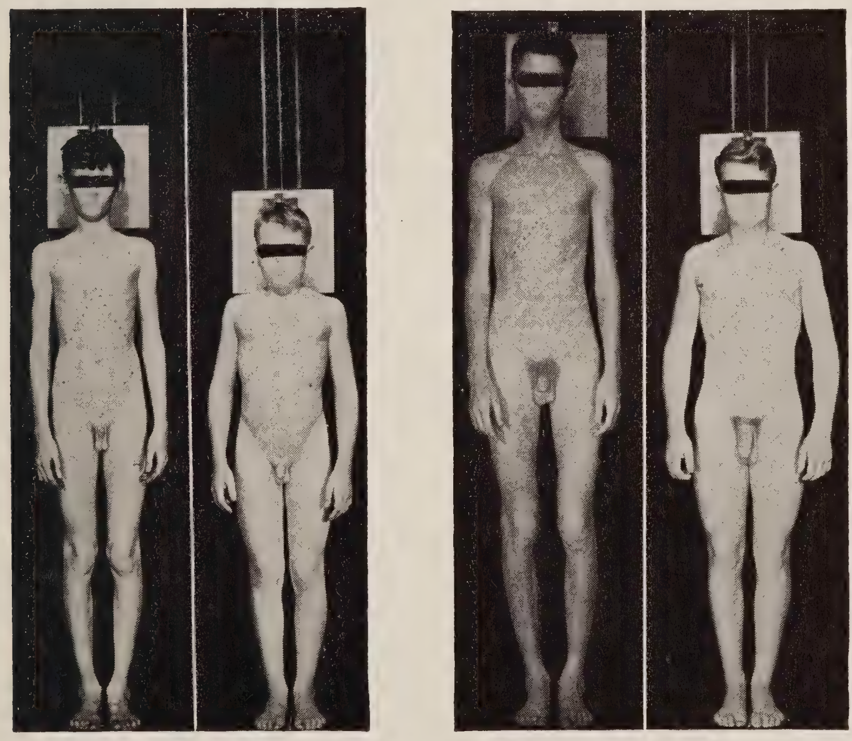


FIGURE 35a. Height curves of two boys (Cases 304 and 32) who began their puberal growth period in height 1.05 years apart but ended it at the same age.



Case 32	**Case 304**	**Case 32**	**Case 304**
C.A. 12.05	13.10	15.15	15.15

Onset of puberal growth period in height.

End of puberal growth period in height.

FIGURE 35b. Photographs of two boys at beginning and end of puberal growth period in height (growth charts presented in Figure 35a). Case 304 began the period 1.05 years after Case 32 but ended it at the same time.

DURATION OF THE PERIOD OF PUBERAL GROWTH

The duration of the puberal growth period in height for boys varied from 1.95 years (Cases 24, 66, and 236) to 4.05 years (Case 180). The distribution of the 67 cases is shown in Figure 36.

Age in years	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
				104						
				242						
				224						
				190						
				100		26				
				120		206				
				108		62				
				60		58				
				176		32				
				154		212				
				116		234				
		134		96		144				
		112		88		218		18		
		304		84		72		230		
		292		80	220	136		168		
		110		52	184	78		294		
		92		50	8	64	216	164		
	66			44	250	54	68	166		
	236	146		40	10	86	244	150		
	24	106	36	34	130	30	82	74		180

FIGURE 36. Distribution of 67 boys by case numbers according to the *duration* in years of the puberal growth period in height: mean, 2.81 years; standard deviation, .53 year; median, 2.85 years; Q_1, 2.45 years; Q_3, 3.16 years.

The mean duration was 2.81 years with a standard deviation of .53 year. The median was 2.85 years with fifty per cent of the cases between 2.45 years and 3.16 years. About one third of the cases (twenty) had a duration between 2.45 years and 2.55 years.

The curves of growth velocity in height and the photographs of three boys chosen as examples of varying duration of the puberal growth in height are presented in Figures 37a and b.

Relation of onset and duration. An analysis was made to see whether there was any relation between the age at onset and the duration of the period. The coefficient of correlation was —.367 with a P.E. of ±.071. The scatter diagram in Figure 38 shows in graphic form the slight tendency of late developers to have a short duration of the puberal growth period in height.

There were two pairs of cases with identical timing of onset and end and therefore of duration. Cases 34 and 52 were relatively late developers, having the onset at 14.15 years and the end at 16.65 years. Cases 234 and

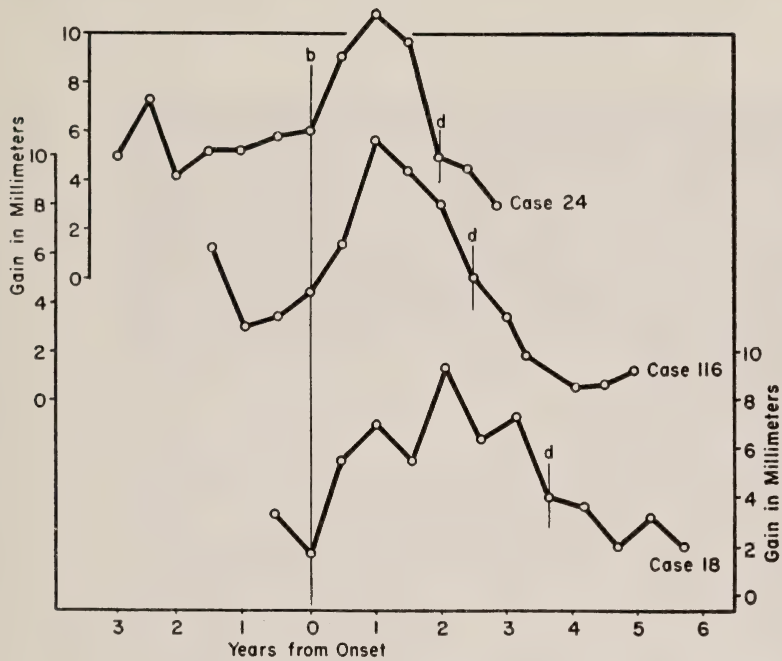


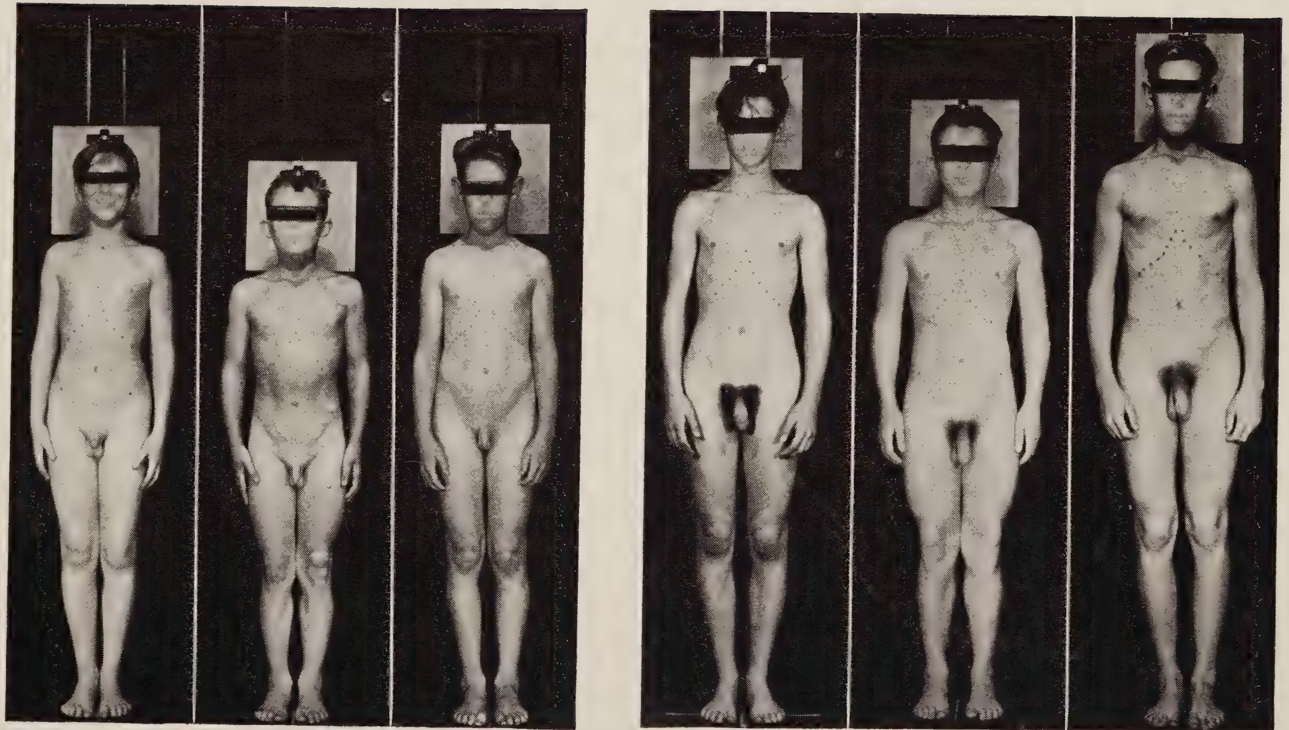
FIGURE 37a. The growth curves of three boys (Cases 24, 116, and 18) arranged to show differences in duration of the puberal growth period in height. Of 67 boys, Case 24 is an example of short duration (1.95 years), Case 116 was near the mode for duration (2.50 years), while Case 18 is an example of long duration (3.65 years).

206 had their onset at 13.10 and 13.05 years and completed the period at 16.15 years, about a half year later than the median.

SUMMARY

In this chapter the puberal growth period for height is defined as the growth around the apex which is above a five year average. Data for 67 boys were available for intensive analysis, with 35 supplementary cases. The age of 102 boys at the onset of the period ranged from 10.40 years to 15.75 years, with the average at 12.88 years. The age of 101 boys at the end of the period ranged from 13.10 years to 17.50 years, with an average of 15.33 years.

The age of the 103 boys when they reached the apex of velocity of their growth in height ranged from 11.90 years to 16.65 years, with a mean of 13.99 years. Our sample of 67 boys had a slightly narrower range but about the same mean. The apex occurred in seventy per cent of the cases within .5 of a year of the mid-point of the puberal period. The range was from .8 year preceding to 1.10 years following the mid-point. The cases were about evenly divided in having the apex before or after the mid-point.



Case 24 Onset | Case 116 | Case 18 | Case 24 End | Case 116 | Case 18

FIGURE 37b. Photographs of the three boys whose curves are presented in Figure 37a, representing short, medium, and long durations of the puberal growth period in height.

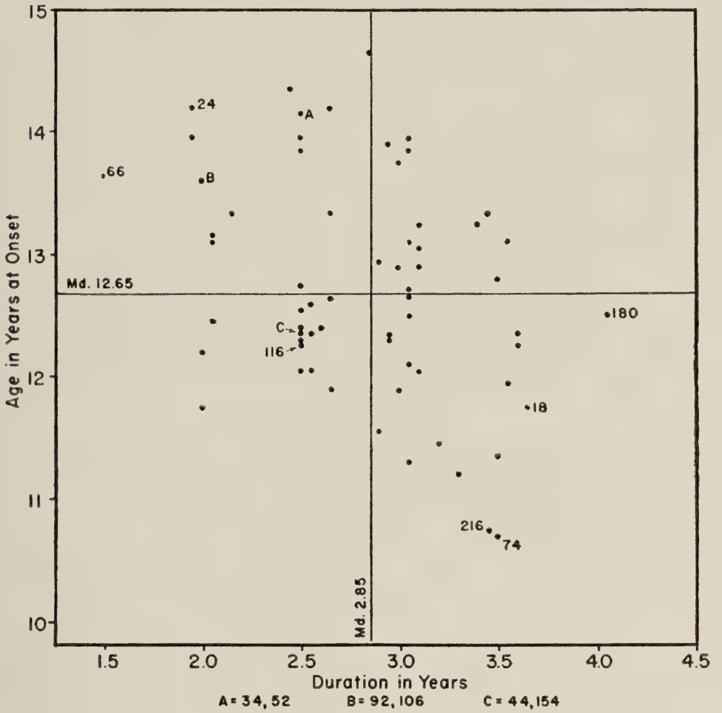


FIGURE 38. Relation of age at the onset of the puberal growth period in height and the duration of the period for 67 boys (Pearson r. —.367, P.E. ± .071). The numbers indicate specific boys by case numbers.

There was considerable overlapping of the ages when the boys started the puberal period, reached the apex of growth, and finished the period. The greatest variety of puberal development was shown among these boys between the ages of 13.75 years and 14.75 years.

The boys who began the puberal growth period early completed the period early, and the ones who began late were late in ending. The correlation between age at onset and at the end of the yeriod was .814, ±.028. However, some boys who began at the same age differed as much as two years in the time when they completed the period.

The duration of the period ranged from 1.95 years to 4.05 years, with a mean of 2.81 years. There was a slight tendency for early developers to have a longer duration than late developers (r. —.367 ±.071).

We may conclude that the period of maximum velocity of growth in height (which we have called the puberal period) shows wide variation in timing for boys. It is frequently stated that the puberal period begins for boys at twelve years of age. According to our definition of the puberal period for height, this would be true for 17.9 per cent of our boys. But

71.6 per cent had not reached the puberal onset for height at that age and 10.4 per cent had passed it. About one third (37.3 per cent) of our boys were within a half year of the puberal onset for height at twelve years of age. Actually, at twelve years of age the boys varied from 2.65 years before the puberal onset for height to 1.30 years after the onset. Chronological age seems to be of very limited use, therefore, as an indication of the developmental status in height growth of boys during adolescence.

FOOTNOTES FOR CHAPTER IV

[1] Shuttleworth, Frank: "The Physical and Mental Growth of Girls and Boys Age Six to Nineteen in Relation to Age at Maximum Growth." *Monograph Society for Research in Child Development,* **4,** No. 3: 1ff, 1939.

[2] See Appendix D.

[3] Data for the 21 boys were made available through the cooperation of Dr. Nancy Bayley, Institute of Child Welfare, University of California.

[4] Data for the 67 boys upon which the discussion of the puberal growth period for height is based will be found in Appendix F.

[5] By courtesy of Dr. Nancy Bayley, Institute of Child Welfare, University of California.

[6] Complete data for 67 cases will be found in Appendix F.

[7] Case 216 is a boy who went through a fat period. The relation of subcutaneous fat development to timing of skeletal development will be discussed in Chapter X. An intensive study of the development of Case 216 is given in Chapter XVIII.

Chapter V GROWTH IN HEIGHT DURING ADOLESCENCE

ALTHOUGH in this study we are concerned primarily with *changes* occurring during adolescence, the measurements of such changes must be derived from measurements and ratings at corresponding points along the course of development. From the analysis of the changes in growth velocity in height we have established two such points, one at the onset of the maximum growth period and one at the end of that period. These points have been designated as "b" and "d" respectively, and the period between them has been called the "puberal growth period."

In addition, we have determined two other points; one preceding and one following the puberal growth period for height. These additional points were determined from systematic inspection of all the growth profiles of more than one hundred boys. The profiles indicated that from one to one and one-half years before the puberal onset for height the profiles for stem length showed a marked and surprisingly consistent dip of about six months duration. In the majority of cases this profile dip bore a consistent relation to similar dips in the profiles for leg length, hip width, and shoulder breadth. This phenomenon of stem length growth appeared to mark a significant developmental point. On the average it occurred 1.25 years before the puberal onset. Since this was within a few months of the third examination preceding b we have designated it as b — 3. From a similar analysis based upon the systematic inspection of growth profiles, it was found that immediately following the close of the puberal period for height (d) the profiles for stem length showed a secondary acceleration–deceleration cycle the mean duration of which was one and one-quarter years. Since the end of this secondary cycle falls within a few months of the third examination following the end of the puberal period for height (d), we have designated it as d + 3. A discussion of the broad base of corroborative evidence upon which these developmental points were selected will be found in Chapter XVI.

In this and suceeding chapters we will present dimensional measurements for our 67 boys at b and d, at the third examination prior to b, which we will call "b — 3," and at the third examination after d, which we will call "d + 3." [1] Thus we can compare the dimensions of the boys in

our sample at a point during the prepuberal period and at a point during the postpuberal period as well as at the onset and the end of the puberal growth period.

HEIGHT MEASUREMENTS IN RELATION TO THE PUBERAL GROWTH PERIOD

The distributions of the 67 boys according to height measurements at the four developmental points are given in Figures 39a, b, c, and d.[2] Table 14 presents a statistical analysis of these data.[3]

								220								
							190	150		250						
					242		184	130		244						
					230		180	120		234						
				304	218	294	164	96	292	144						
				212	166	216	154	84	176	112						
				108	136	206	146	78	106	54						
	116			60	100	110	80	72	86	50	168		104			
	62			24	82	88	64	68	58	36	66		224			
	40		92	10	44	26	18	30	8	34	52	134	32	236		74*
Millimeters	1,320	1,340	1,360	1,380	1,400	1,420	1,440	1,460	1,480	1,500	1,520	1,540	1,560	1,580	1,600	1,620

FIGURE 39a. Distribution of 67 boys by case numbers according to measurements of height in millimeters during the prepuberal period (b — 3). Mean, 1,461.57 millimeters; standard deviation, 60.80 millimeters; median, 1,461.00 millimeters; Q_1, 1,416.88 millimeters; Q_3, 1,502.78 millimeters.

* Data taken at one examination preceding onset (b — 1).

									296						
									6						
					170				130						
					12	*140*			120		*162*				
					292	150			96	*178*	234				
				216	242	110	190		58	*158*	144				
				212	88	64	180		30	*4*	50				
				108	82	230	86		220	106	292	*228*			
				26	218	206	80		146	68	176	168			
			142	60	100	166	78		184	8	54	112		224	
		40	*118*	10	44	136	164		84	250	36	66	*90*	134	236
	116	62	*2*	304	92	24	18	154	72	244	34	52	104	32	74
Millimeters	1,360	1,380	1,400	1,420	1,440	1,460	1,480	1,500	1,520	1,540	1,560	1,580	1,600	1,620	1,640

FIGURE 39b. Distribution of 81 boys (67 cases plus 14 supplementary cases in italics) by case numbers according to measurements in height in millimeters at the onset of the puberal growth period of height. Statistics for 67 cases: mean, 1,518.16 millimeters; standard deviation, 61.06 millimeters; median, 1,518.07 millimeters; Q_1, 1,473.87 millimeters; Q_3, 1,562.60 millimeters. Statistics for 81 cases: mean, 1,514.68 millimeters; standard deviation, 62.12 millimeters; median, 1,515.71 millimeters; Q_1, 1,468.50 millimeters; Q_3, 1,561.67 millimeters.

mm	Case numbers
1,540	*102*
1,560	116, 40
1,580	*118*, 304
1,600	*56*, *2*, 92, 62, 60
1,620	*114*, 24
1,640	*140*, *4*
1,660	*6*, 212, 10, 242, 218, 44
1,680	*300*, *170*, 206, 154, 110, 100, 88, 294, 108
1,700	*302*, *172*, *14*, 190, 176, 136, 78, 64, 18, 146
1,720	*42*, 130, 120, 106, 96, 84, 80, 26, 34, 216, 220, 66, 58
1,740	*162*, 164, 72, 54, 36, 8, 292, 166, 86, 82
1,760	250, 224, 150, 230, 184, 112, 30
1,780	134, 68, 52, 50, 236
1,800	180, 244, 104
1,820	*232*, 168, 144
1,840	234
1,860	32
1,880	
1,900	
1,920	74

FIGURE 39c. Distribution of 83 boys (67 plus 16 supplementary cases in italics) by case numbers according to measurements in height in millimeters at the end of the puberal growth period in height. Statistics for 67 cases: mean, 1,729.17 millimeters; standard deviation, 66.38 millimeters; median, 1,733.15 millimeters; Q_1, 1,690.47 millimeters; Q_3, 1,768.25 millimeters. Statistics for 83 cases: mean, 1,719.23 millimeters; standard deviation, 69.15 millimeters; median, 1,723.32 millimeters; Q_1, 1,681.25 millimeters; Q_3, 1,760.93 millimeters.

mm	Case numbers
1,580	*102*
1,600	40, 116
1,620	*118*, *2*, 304
1,640	62, 60
1,660	218, 92
1,680	*114*, *6*, *4*, 212, 24
1,700	294
1,720	*300*, *170*, *140*, 242, 154, 108, 10
1,740	*172*, *56*, *14*, 220, 216, 206, 190, 146, 130, 88, 78, 66, 44, 18
1,760	*302*, *42*, 176, 166, 136, 110, 106, 100, 84, 80, 64, 58, 34, 8
1,780	*162*, 230, 164, 120, 96, 86, 82, 72, 54, 36, 30, 26
1,800	292, 250, 244, 236, 224, 184, 150
1,820	180, 134, 112, 68, 52
1,840	168, 105, 50
1,860	*232*
1,880	234, 144
1,900	32
1,920	
1,940	74

FIGURE 39d. Distribution of 83 boys (67 plus 16 supplementary cases in italics) by case numbers according to measurements of height in millimeters during the post-puberal period (d + 3). For 67 cases: mean, 1,770.39 millimeters; standard deviation, 64.66 millimeters; median, 1,774.17 millimeters; Q_1, 1,745.00 millimeters; Q_3, 1,806.42 millimeters. For 83 cases: mean, 1,760.19 millimeters; standard deviation, 69.72 millimeters; median, 1,765.62 millimeters; Q_1, 1,729.30 millimeters; Q_3, 1,798.90 millimeters.

At the third examination preceding the onset of the puberal period (b — 3), which closely approximated the beginning of the prepuberal period, the 67 boys ranged in height from 1,332 millimeters (52.36 inches) to 1,599 millimeters (62.95 inches), a difference between the tallest and shortest boy of 267 millimeters (10.59 inches).[4] The mean height was 1,461.57 millimeters (57.56 inches) with a standard deviation of 60.80 millimeters (2.39 inches). (See Figure 39a.)

Table 14 HEIGHT MEASUREMENTS DURING ADOLESCENCE—67 BOYS

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3	*Coefficient of Variation*
A. In Millimeters							
Prepuberal (b − 3)	1,332–1,625*	1,461.57	60.80	1,461.00	1,416.88	1,502.78	4.30
Onset of puberal growth period (b)	1,375–1,659	1,518.16	61.06	1,518.07	1,473.87	1,562.60	4.02
End of puberal growth period (d)	1,570–1,922	1,729.17	66.38	1,733.15	1,690.47	1,768.25	3.83
Postpuberal (d + 3)	1,611–1,955	1,770.39	64.66	1,774.17	1,745.00	1,806.42	3.65
Puberal gain (b–d)	121–299	212.15	38.70	211.29	187.45	233.25	
B. In Inches							
Prepuberal (b − 3)	52.44–63.98*	57.54	2.39	57.54	55.78	59.17	
Onset of puberal growth period (b)	54.14–65.31	59.77	2.40	59.76	58.00	61.52	
End of puberal growth period (d)	61.81–75.67	68.08	2.61	68.24	66.56	69.61	
Postpuberal (d + 3)	63.43–76.97	69.71	2.55	69.86	68.70	71.12	
Puberal gain (b–d)	4.76–11.77	8.36	1.52	8.32	7.36	9.19	

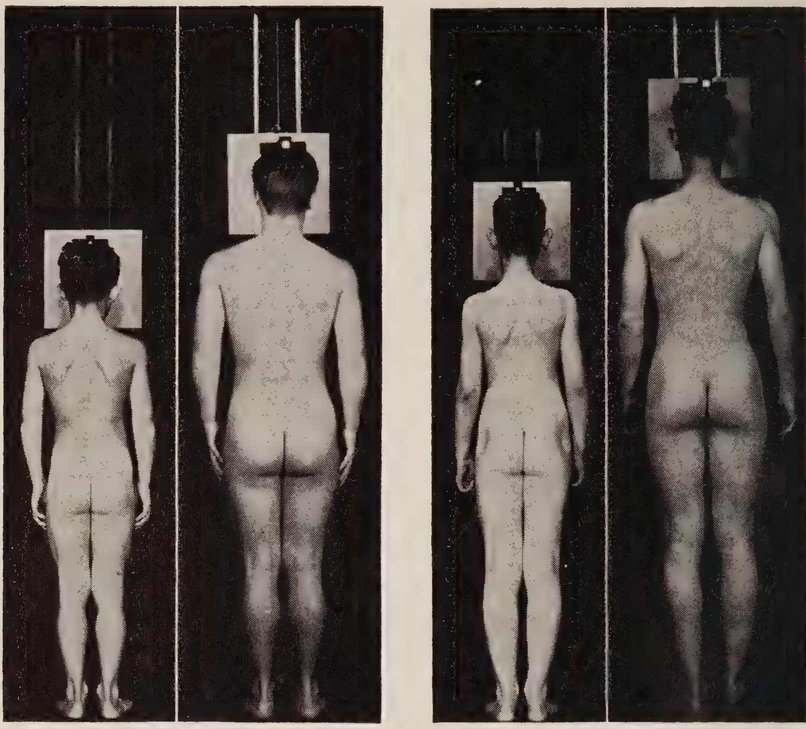
* Data for Case 74, the tallest boy, were taken at b − 1. With Case 74 eliminated, the range was 1,332–1,599 millimeters (52.44–62.95 inches.)

At the onset of the puberal period the shortest boy among the 67 cases measured 1,375 millimeters (54.14 inches) and the tallest 1,659 millimeters (65.31 inches). In range of difference (284 millimeters or 11.18 inches) this was a slight increase over the difference during the prepuberal period. Case 116 was the shortest and Case 236 the tallest. Case 236 was extremely tall at onset because he was a late developer and had a long prepuberal period of relatively high growth. The mean height increased to 1,518.16 millimeters (59.77 inches). Data for fourteen supplementary cases have been added to the distribution in Figure 39b. These additional cases fell within the range of the original 67 cases and do not change the general form of the distribution. There was practically no difference in the mean height, a change from 1,518.16 millimeters (59.77 inches) to 1,514.68 millimeters (59.64 inches).

By the end of the puberal period the mean height had increased to 1,729.17 millimeters (68.08 inches). Of the 67 cases, Case 116 was still the shortest, measuring 1,570 millimeters (61.81 inches), and Case 74 the tallest, measuring 1,922 millimeters (75.67 inches). This was a difference of 352 millimeters (13.86 inches), an increase over the onset range. In Figure 39c we have added sixteen supplemental cases to the original group. One case lowers the range slightly to 1,550 millimeters (61.02 inches). Of the 16 supplemental cases, 13 were below the mean height of the intensive example of 67 cases. This fact lowered the average height for the group of 83 boys about a quarter of an inch.

The overlapping between the heights of the boys at the onset and end of the puberal period should be noted. There were 13 boys out of the larger sample of 83 cases who were shorter at the end of their puberal growth than some of the boys were at the beginning. Of these 13 there were 7 in our intensive sample of 67 boys.

At the third examination following the end of the puberal period (d + 3), which closely approximated the end of the postpuberal period, the mean increased slightly to 1,770.39 (69.71 inches). The range between the shortest boy and the tallest boy was from 1,611 millimeters (63.43 inches) to 1,955 millimeters (76.97 inches), a difference of 344 millimeters (14.41 inches). This range was slightly less than the range at the end of the puberal period. Among the 67 cases the same boys were still the shortest (Case 116) and the tallest (Case 74). Data for sixteen supplementary cases were available for the distribution of height measurements at d + 3 in the postpuberal period. Of these, four cases fell close to the median in the distribution, and twelve cases fell below the median. (See Figure 39d.) One case (Case 102) extended the lower end of the range by 9 millimeters (.35 inch).



Case 116 **Case 120**

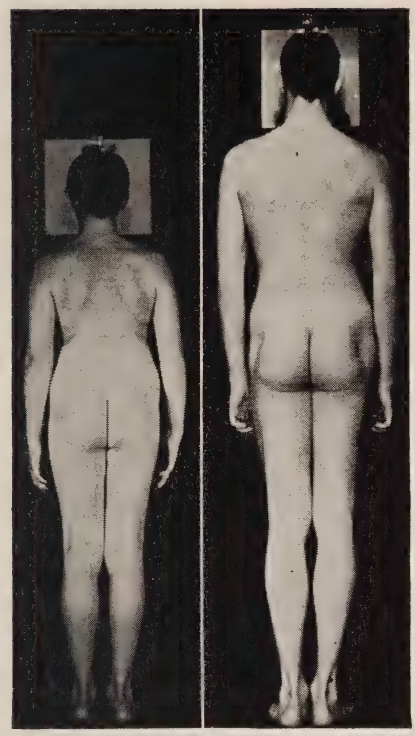
At point b − 3 | At point d + 3 | At point b − 3 | At point d + 3

FIGURE 40.

Five boys (Cases 40, 60, 62, 92, and 116) remained consistently among the ten per cent shortest in the study. However, only two boys (Cases 74 and 32) remained consistently among the ten per cent tallest boys. The photographs of three boys are shown in Figure 40. One was consistently the shortest (Case 116), one the tallest except at puberal onset (Case 74), and one consistently near the mean for the group of 67 boys (Case 120).

It can be seen from Figures 39a, b, c, and d that the distribution of cases becomes progressively more close knit as the boys become more mature. This is substantiated by the steadily decreasing coefficient of variation from the point in the prepuberal period to the point in the postpuberal period. (See Table 14.)

Relation of height and age at puberal onset. There was no general relation between the age of a boy and his height at the puberal onset. The coefficient of correlation for the 67 boys was .143, with a probable error of ±.081. By adding to our sample 14 supplementary cases for whom data were available, the correlation for the total 81 boys between age and height



Case 74

At point b — 1 At point d + 3

FIGURE 40. Photographs of three boys during the prepuberal period (b — 3) and during the postpuberal period (d + 3). Case 116 was consistently the shortest boy in the study; Case 120 was consistently close to the height mean of the group; Case 74 was the tallest except at puberal onset. The growth curves for these boys will be found on the following pages: Case 116, Figure 37a, page 69; Case 120, Figure 29, page 56; Case 74, Figure 125b, page 223.

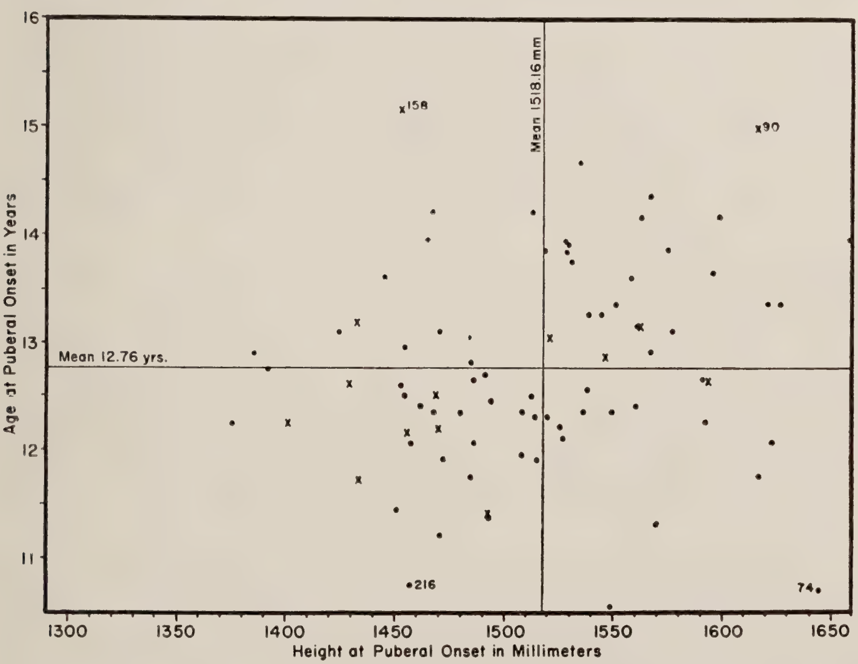


FIGURE 41. Relation of height and chronological age at onset of the puberal growth period for height for 67 boys. Coefficient of correlation .143 (P.E. ± .081).

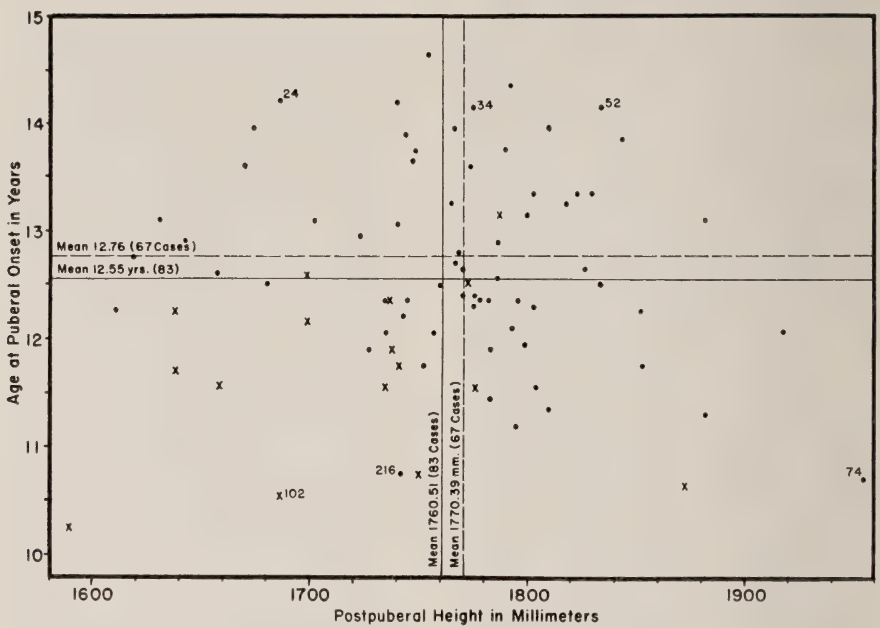


FIGURE 42. Relation of age at the onset of the puberal growth period and height at d + 3 in the postpuberal period. Coefficient of correlation for 67 boys —.219 (P.E. ± .065). The cases marked on the diagram are shown in Figures 43a and b. The sixteen supplementary cases are indicated by x.

at onset increases to .227, with a probable error of ±.071. The scatter diagram in Figure 41 shows the relation of these two factors. Of the two youngest boys, one was the next to tallest (Case 74), but the other was below the mean in height (Case 216). Of the two oldest, one was in the lowest quartile for height and the other in the upper quartile (supplementary Cases 158 and 90).

Relation of age at onset to postpuberal height. One of the questions which is continually being asked is whether the early developers are likely to be the tallest men. We endeavored to find the answer to that question on the basis of our criterion of early and late developers: namely, the age of onset of the puberal growth period in height. For this purpose we analyzed first the 67 cases in our sample. We then added 16 cases for whom we had data adequate for this purpose though insufficient for the total analysis of the study.[5]

The scatter diagram in Figure 42 gives the relationship of the age at onset to postpuberal height for both the 67 cases and the 83 cases. Table 15 gives a summary of these data. It is easy to see that there is very little evidence of any consistent relationship between age at onset of the puberal period and later height. The early and late developers scattered

rather generally along the whole range of height at the postpuberal point d + 3.

The early developers had a somewhat wider range in height at the postpuberal period than the late developers. The two shortest and the two tallest boys were both early developers.

Table 15 RELATION OF AGE AT ONSET TO POSTPUBERAL HEIGHT

A. On Basis of 67 Boys

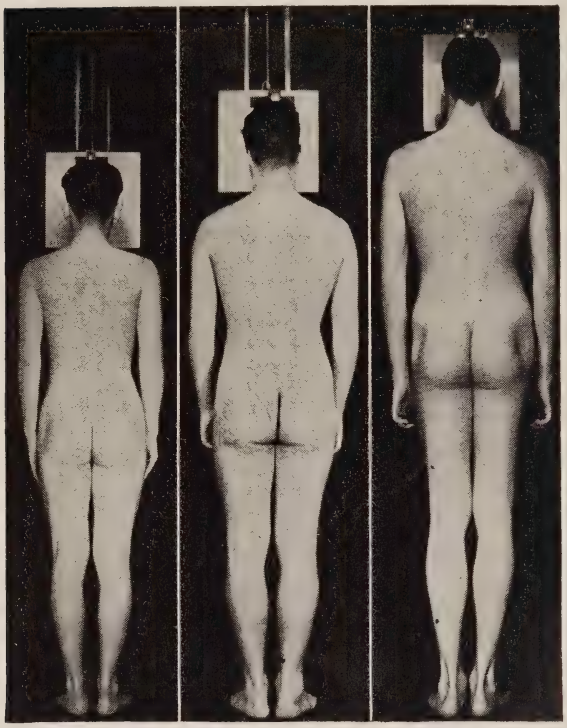
Relation to Mean Age 12.76 years	*Relation to Mean Height* 1770.39 millimeters	*Number of Cases*	*Per Cent*
Early	Short	15	22.39
Early	Tall	21	31.34
Early	Mean	1	1.49
		37	55.22
Late	Short	16	23.88
Late	Tall	14	20.89
		30	44.77

B. On Basis of 83 Boys

Relation to Mean Age 12.55 years	*Relation to Mean Height* 1760.51 millimeters	*Number of Cases*	*Per Cent*
Early	Short	21	25.30
Early	Tall	23	27.71
Early	Mean	1	1.49
		45	54.50
Mean	Tall	1	1.49
Late	Short	16	19.28
Late	Tall	21	25.30
		37	44.58

If we look at Table 15, we find that 46.67 per cent of the early developers were below the mean in height at the postpuberal period and 52.22 per cent were above the mean. If we look at the tall boys, 52.27 per cent had their onset before the mean. This may indicate that there is a likelihood that more early developers will be tall than short, but it is not very convincing evidence. This doubtful relation is substantiated by the Pearson coefficient of correlation of —.219 (P.E. ±.065) between age at onset of the puberal period and height during the postpuberal period.

In Figures 43a, b, and c are presented photographs of boys which illustrate some of the varying patterns of interrelations of timing and growth in

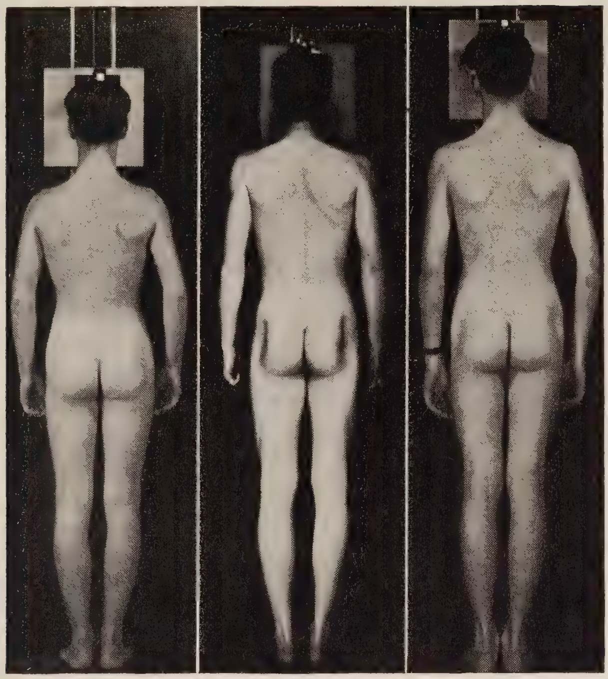


Case 102	Case 216	Case 74
14.6 years	15.5 years	15.4 years
Height 1,685 millimeters.	Height 1,742 millimeters.	Height 1,955 millimeters.

FIGURE 43a. Photographs of three boys (Cases 102, 216, and 74), taken at a corresponding point in the postpuberal period, which illustrate our finding that boys who develop earliest do not necessarily become tall men. Each of these boys was a very early developer, but their final height varied greatly: one became a short man, one medium in height, and one a tall man. Growth curve for Case 216 will be found in Figure 33a, page 61; for Case 74 in Figure 125b, page 223.

height. Figure 43a illustrates early developing boys who attained varying heights. Figure 43b illustrates late developers who attained varying heights. Figure 43c shows that either early or late developers may become tall.

Relation of height at onset and end of the puberal growth period. The scatter diagram in Figure 44 shows a close correlation between the height of a boy at the onset of the puberal growth period and his height at the end of that period. The Pearson coefficient of correlation was .819 P.E. $\pm$.027. There were a few boys who did not attain the height which might have been expected. These included Cases 236, 134, 224, and 66, all of whom were late developers with a long, high level of prepuberal growth.



Case 24	Case 34	Case 52
17.3 years	18.1 years	17.9 years
Height 1,686 millimeters.	Height 1,775 millimeters.	Height 1,834 millimeters.

FIGURE 43b. Photographs of three boys taken at corresponding points in the post-puberal period. These boys were all late developers (onset at about 14.2 years). One boy's final height was short, another medium, and the third tall. Growth curves for these cases will be found in the following figures: Case 24, Figure 37a, page 69; Case 34, Figure 124d, page 219; Case 52, Figure 122b, page 210.

The 7 supplementary cases added in Figure 44 serve to substantiate the correlation found for the 67 boys.

PUBERAL GAIN IN HEIGHT

There was wide variation in the amount of height gained during the puberal growth period. The distribution of the 67 boys is given in Figure 45. Case 236 gained only 121 millimeters (4.76 inches), while Case 180 gained 299 millimeters (11.77 inches). The mean gain was 212.15 millimeters (8.35 inches) with a standard deviation of 38.7 millimeters (1.52 inches). The median was 211.29 millimeters (8.31 inches). Fifty per cent of the cases gained between 187.45 millimeters (7.37 inches) and 233.25 millimeters (9.18 inches).

Case 232 15.4 years Height 1,872 mm

Case 50 17.6 years Height 1,844 mm

FIGURE 43c. Photographs illustrating our finding that tall boys may be early or late developers. Case 232 began the puberal growth period at 10.65 years, while Case 50 did not begin until 13.85 years. Photographs were taken at similar points in the postpuberal period. Both boys were in the upper ten per cent of the group in height.

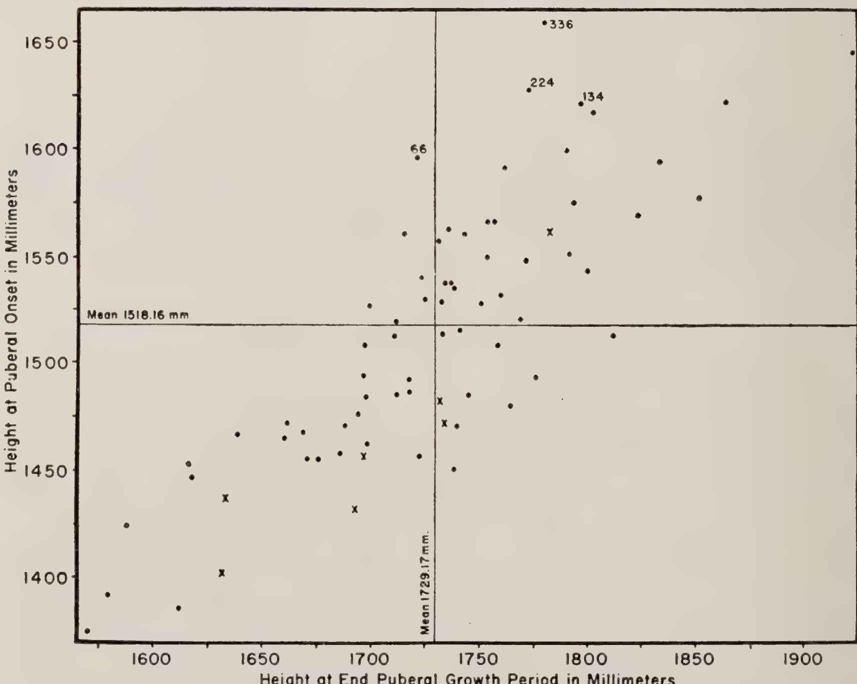


FIGURE 44. Relation of height at onset and end of puberal growth period for 67 boys. Coefficient of correlation .819 (P.E. $\pm$ .027). X indicates supplementary cases.

								220										
								218			108							
								190			86							
						134		116			64							
						92		96	84	294	62							
						146	104	242	130	212	30							
						112	54	154	120	88	18		184					
						106	58	78	110	80	250		168	244	216		26	
	66				304	34	40	52	44	50	72	100	68	164	82	234	230	
	236		224	176	60	24	292	36	8	206	10	136	32	144	166	74	150	180
Millimeters	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290

FIGURE 45. Distribution of 67 boys by case numbers according to amount of gain in height in millimeters during puberal growth period: mean, 212.15 millimeters (8.36 inches); standard deviation, 38.7 millimeters (1.52 inches); median, 211.29 millimeters (8.32 inches); Q_1, 187.45 millimeters (7.36 inches); Q_3, 233.25 millimeters (9.19 inches).

Relation of actual gain to percentage gain. There was a high correlation between the actual puberal gains in height and the percentage gains, r. .973, P.E. ±.004. The boy with the lowest actual gain also had the lowest percentage gain (Case 236); the same boy who made the highest actual gain made the highest percentage gain (Case 180). The range in percentage gain was from 7.3 per cent to 19.5 per cent with a mean of 13.90 per cent, S.D. 2.63 per cent. Fifty per cent of the 67 cases made a percentage puberal gain in height between 11.63 per cent and 14.56 per cent. Figure 46 shows the distribution of 67 cases by percentage gain in height during the puberal period.

								86					
							218	294					
					304		130	250					
					54	220	50	212					
					92	242	44	72	18	144			
					24	96	110	30	168	74			
					292	78	40	32	108	164			
					146	154	84	88	136	244			
				104	60	36	8	80	68	184		216	26
	66			134	106	52	190	206	10	62	166	150	180
	236	224	176	112	34	58	120	116	64	100	234	82	230
Per cent gain	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0

FIGURE 46. Distribution of 67 boys by case numbers according to the percentage gain in height during the puberal period: mean, 13.90 per cent; standard deviation, 2.63 per cent.

The photographs and growth curves in Figures 47, 48, and 49 are of three boys, one who gained a relatively small amount (Case 236), one who

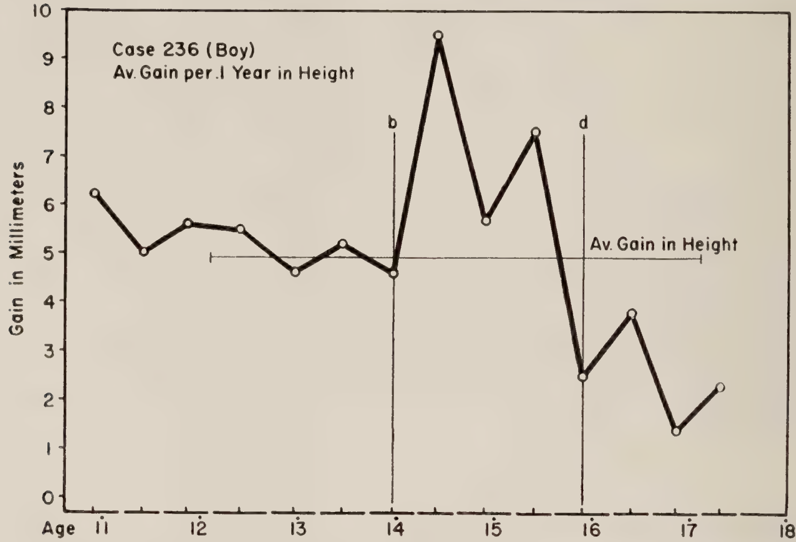


FIGURE 47a. Growth curve of a boy (Case 236) who gained a relatively small amount in height (121 millimeters or 4.76 inches) during his puberal growth period.

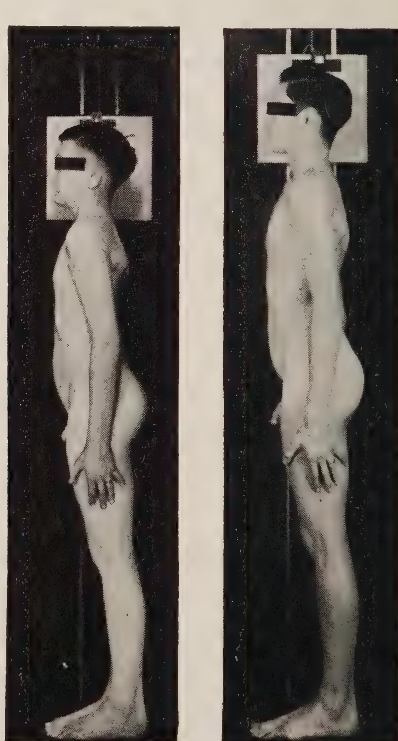


FIGURE 47b. Photographs of Case 236 at onset and end of puberal growth period. (See growth curve in Figure 47a.)

gained about the median amount for the group (Case 110), and one who made the greatest gain in height of any boy in the study during the puberal growth period (Case 180).

Case 236 (Figures 47a and b) gained only 121 millimeters (4.76 inches) between 13.95 years and 15.90 years. In considering the factors which may have contributed to this, it may be noted that at the onset of the puberal growth period, which was relatively late (13.95 years), he had already achieved 91 per cent of his final height at 17.5 years.[6] It can be readily seen in the curve in Figure 47a that this was due partly to an unusually high level of height growth between 11.2 years and 13.2 years, which was prior to the onset of the puberal growth period. In addition, the duration of his puberal growth period (1.95 years) was next to the shortest of the group. And, third, he was one of the boys who passed through a period of significant increase in subcutaneous fat development.[7]

Case 110 (Figures 48a and b) gained 203 millimeters (7.99 inches) during his puberal growth period. This was thirteen per cent of his height at the onset. He illustrates a boy who made about an average increase in height. Prior to the onset of this period he had gained 83 per cent of his final height at 17.2 years. The duration of his puberal growth period was 2.05 years. Only 5 of the 67 cases had a shorter duration. However he continued to make a substantial gain during the postpuberal period. He showed no signs of having passed through a fat period.

Case 180 (Figures 49a and b) gained 299 millimeters (11.77 inches) during his puberal growth period, the greatest gain in height of any boy in the study. Prior to the onset of the period he had gained 83 per cent of his final height at 17.3 years—less than Case 236 but the same as Case 110. In contrast to the others, however, he had the longest duration of any boy in the study—4.05 years. This was .4 of a year longer than any other boy; 2 years longer than Case 110 and 2.10 years longer than Case 236. He made very little gain after the puberal period. It is interesting to note that Cases 180 and 236 were among the four boys in the study whose stem length was consistently less than fifty per cent of their height.

Relation of gain in height to duration of puberal period. The scatter diagram in Figure 50 shows the relation of total gain in height during the puberal growth period to the duration of the period. The Pearson coefficient of correlation is .771, P.E. $\pm$.033, which indicates what we might expect; namely, that in general the longer the period the greater the gain. However, there were cases of slight and prolonged growth as well as cases of rapid intense growth. The two extreme cases are interesting: Case 236 who gained 121 millimeters (4.76 inches) in 1.95 years, and Case 180 who gained 299 millimeters (11.8 inches), almost two and a half times as

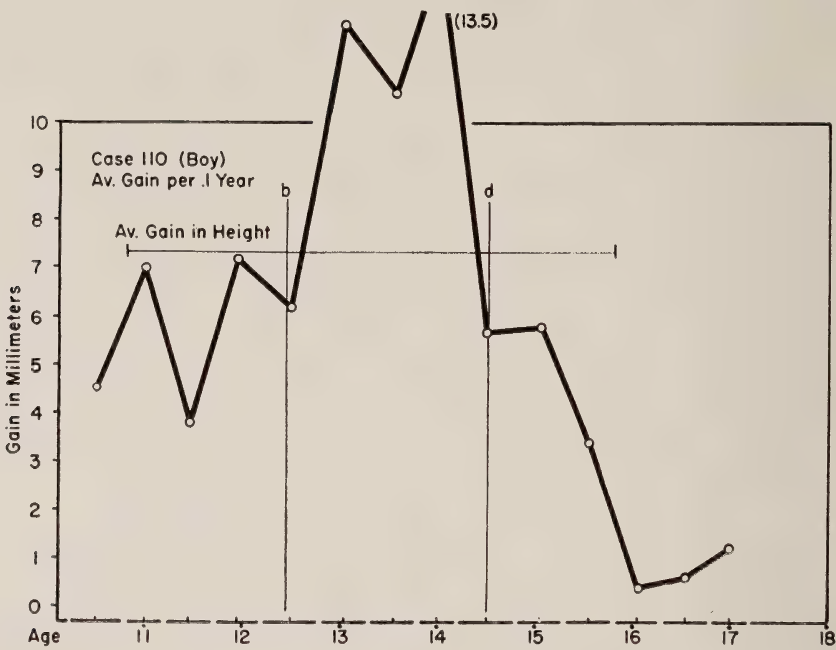


FIGURE 48a. Growth curve of a boy (Case 110) who made about an average gain in height during the puberal growth period (203 millimeters or 8 inches).

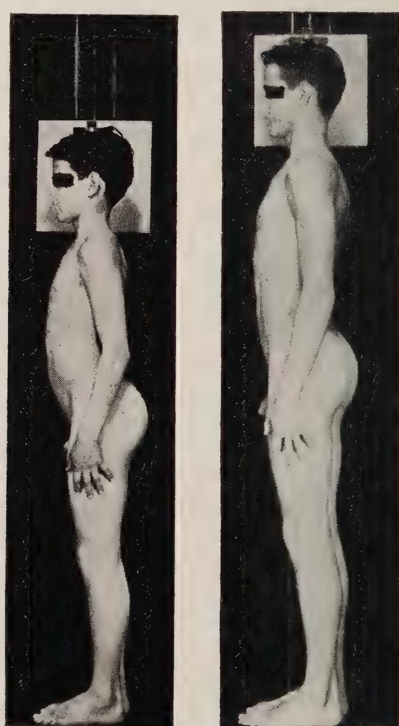


FIGURE 48b. Photographs of Case 110 at onset and end of puberal growth period. (See growth chart, Figure 48a.)

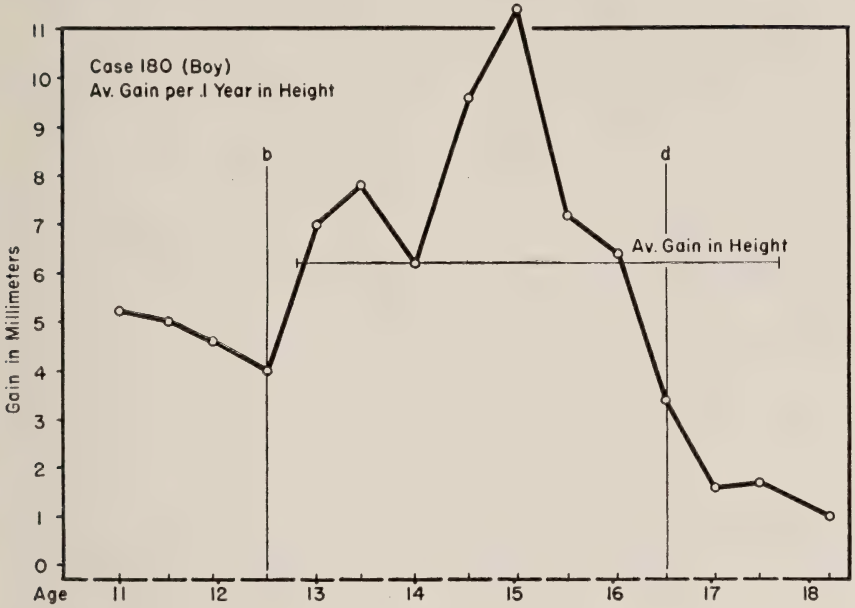


FIGURE 49a. Growth curve of a boy (Case 180) who gained more than any other boy in height during his puberal growth period (299 millimeters or 11.77 inches).

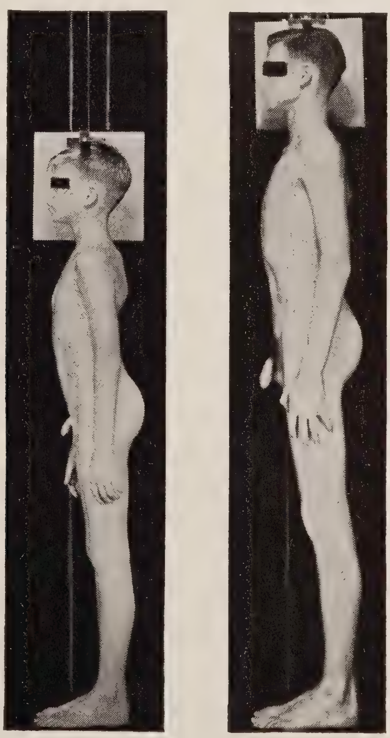


FIGURE 49b. Photographs of Case 180 at onset and end of puberal growth period. (See growth chart in Figure 49a.)

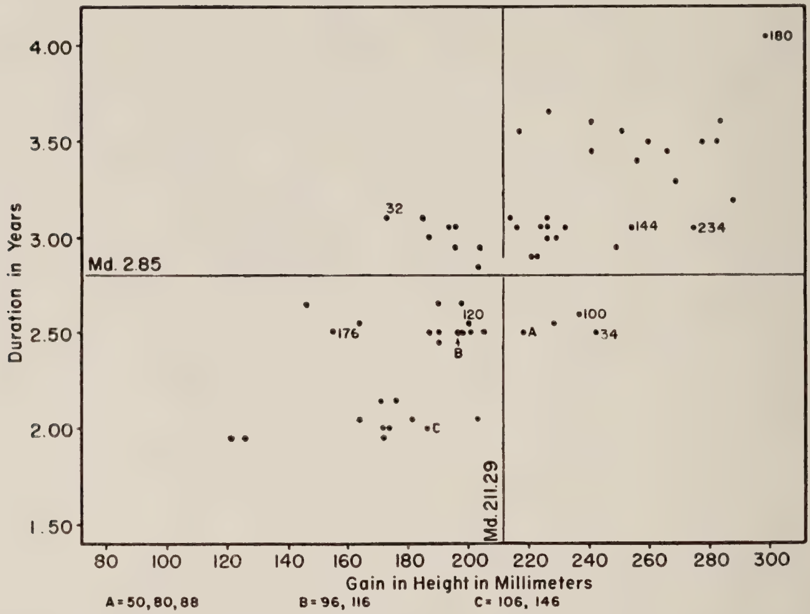


FIGURE 50. Relation of gain in height to duration of the puberal growth period in height for 67 boys. Coefficient of correlation .771 (P.E. ± .033). Numbers refer to specific cases.

much as Case 236, over a period of 4.05 years (a span twice as long as the span of Case 236). These are the two cases presented in Figures 47 and 48.

There are three cases outside of the general trend—Cases 32, 34, and 100. Case 32 gained only 173 millimeters (6.8 inches) in 3.1 years—a slow and prolonged growth. Cases 34 and 100 had rapid, intense growth. Case 34 (among the oldest at the onset of his puberal growth period in height) gained 242 millimeters (9.53 inches) in 2.50 years, and Case 100 gained 237 millimeters (9.34 inches) in 2.6 years.

Of the 67 boys there were a few who made similar gains in the same amount of time (two pairs and four groups of three boys each). These are shown in Table 16. Although not identical, the close similarity in amount of gain and duration should be noted among Cases 52, 154, 96, 120, and 116, and among Cases 10, 250, 30, 64, and 86.

Among the cases in Table 16 perhaps the two most interesting are Cases 96 and 120 because of the unusual similarity of their patterns of growth in height, not only in timing but in gross measurements and puberal gain.

Table 16 SIMILAR GAIN IN HEIGHT AND SIMILAR DURATION OF PUBERAL GROWTH PERIOD

Case	*Onset Age* Years (b)	*End Age* Years (d)	*Duration* Years (b–d)	*Gain* Millimeters (b–d)	*Onset Height* Millimeters (b)	*End Height* Millimeters (d)
52	14.15	16.65	2.50	192	1,599	1,791
154	12.35	14.85	2.50	190	1,508	1,698
10	12.95	15.85	2.90	221	1,455	1,676
250	11.55	14.45	2.90	222	1,549	1,771
96	12.55	15.05	2.50	198	1,537	1,735
120	12.35	14.90	2.55	200	1,537	1,737
116	12.25	14.75	2.50	195	1,375	1,570
92	13.60	15.60	2.00	172	1,446	1,618
106	13.60	15.60	2.00	174	1,558	1,732
146	12.20	14.20	2.00	174	1,526	1,700
50	13.85	16.35	2.50	219	1,575	1,794
80	12.30	14.80	2.50	219	1,514	1,733
88	12.05	14.55	2.50	218	1,476	1,694
30	13.75	16.75	3.00	229	1,531	1,760
64	12.70	15.75	3.05	226	1,492	1,718
86	11.90	14.90	3.00	226	1,515	1,741

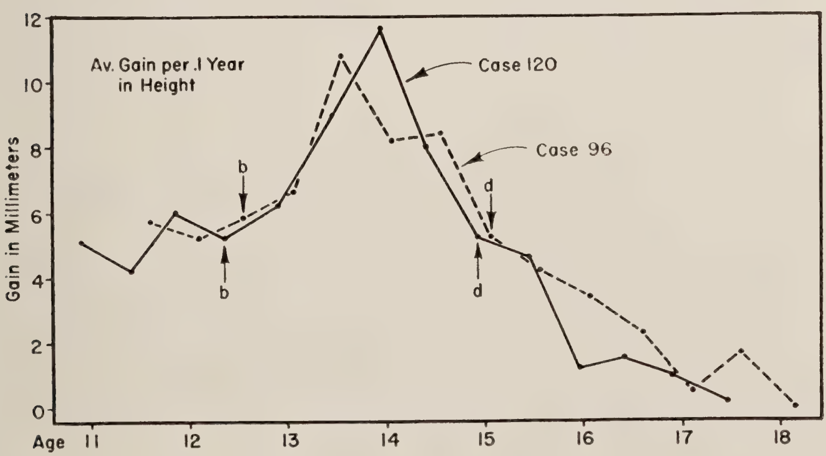
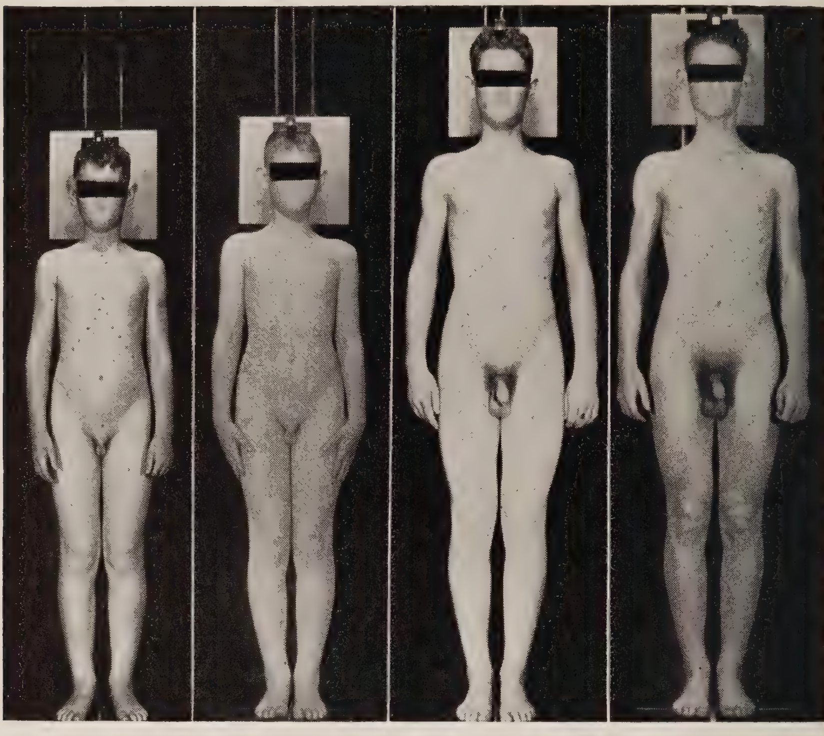


FIGURE 51a. Height curves of two boys (Cases 96 and 120) who had unusual similarity in growth patterns. These boys began the puberal growth period within three months of the same age. They were the same height at the time–1537 millimeters or 60.5 inches. The puberal period was 2.50 years for each; there was only two millimeters difference in their gains, and, therefore, they were about the same height at the end of the period–1735 and 1737 millimeters, 68.3 inches. In the postpuberal period (d + 3) there was only .16 of an inch difference in their heights.

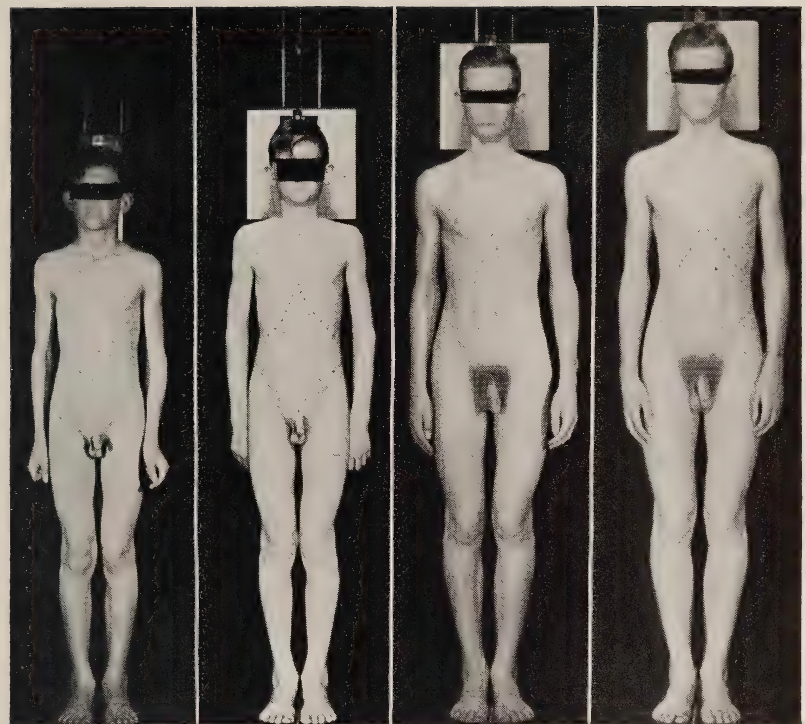


Case 120

C.A. 11.3	12.3	14.9	16.2
Prepuberal	Puberal onset	Puberal end	Postpuberal

Two other boys (Cases 144 and 234) also had very similar patterns of growth. They were within 7 millimeters of being the same height at onset; at the end of the puberal period, which lasted 3.05 years for each, they were 28 millimeters apart, but by d — 3 in the postpuberal period they were identical in height. The height growth curve for Case 144 will be found in Figure 122d, page 211 and for Case 234 in Figure 52a, page 93. Growth curves and photographs of Cases 96 and 120 are presented in Figures 51a and b, pages 91, 92 and 93.

It should be pointed out, however, that even when the duration of the puberal growth period in height is the same for two boys, their total gain can vary greatly. Cases 78 and 234 both had a duration of 3.05 years, but the former gained only 194 millimeters (7.64 inches) during that time, while the latter gained 275 millimeters (10.8 inches). (See Figures 52a and b.) Similarly, although the duration of the period of puberal growth



Case 96

C.A. 11.3	12.5	15.0	16.3
Prepuberal	Puberal onset	Puberal end	Postpuberal

FIGURE 51b. Photographs of the two boys described in Figure 51a who showed unusual similarity in height growth patterns.

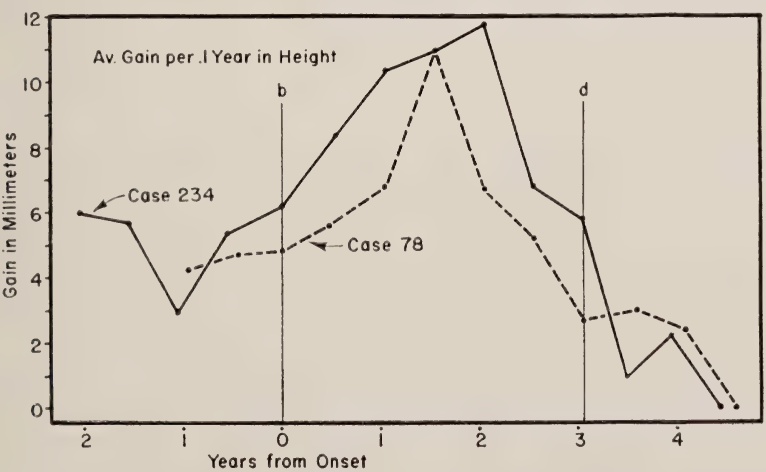
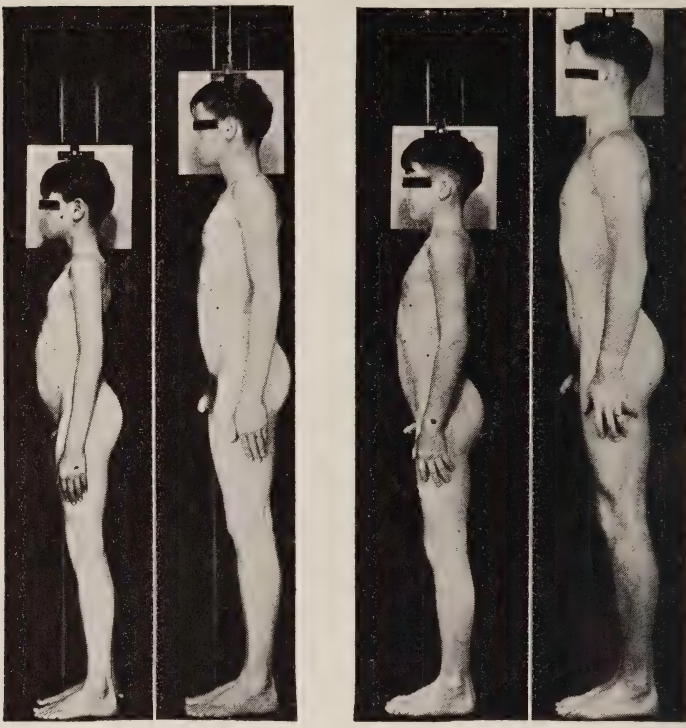


FIGURE 52a. Height growth curves for two boys. Case 78 gained only 194 millimeters (7.64 inches), while Case 234 gained 275 millimeters (10.8 inches) during puberal periods which lasted 3.05 years. (See photographs in Figure 52b.)



Case 78 **Case 234**

C.A. 13.85 16.90 13.10 16.15

Onset End Onset End

FIGURE 52b. Comparison of photographs of two boys at onset and end whose duration of puberal growth period in height was 3.05 years, but who gained different amounts in height. (See growth curves in Figure 52a.)

in height was 2.5 years for both, Case 176 only gained 155 millimeters (6.1 inches), while Case 34 gained 242 millimeters (9.53 inches).

There are also cases (three pairs out of 67 cases) where the amount gained in height was identical, but the duration varied widely. For example, Case 58 took 3.10 years to gain 185 millimeters (7.28 inches), while Case 104 gained the same amount in a year less time (2.00 years). Case 294 contrasts sharply with Cases 50, 80, and 88 described in Table 16, since Case 294 took 3.55 years to gain the same amount the other three gained in 2.5 years. Case 108 took only 2.55 years to gain 228 millimeters (8.97 inches), while Case 18 took 3.65 years to gain the same amount. These boys began the puberal growth period in height within 3.6 months of each other. (See Figures 53a and b).

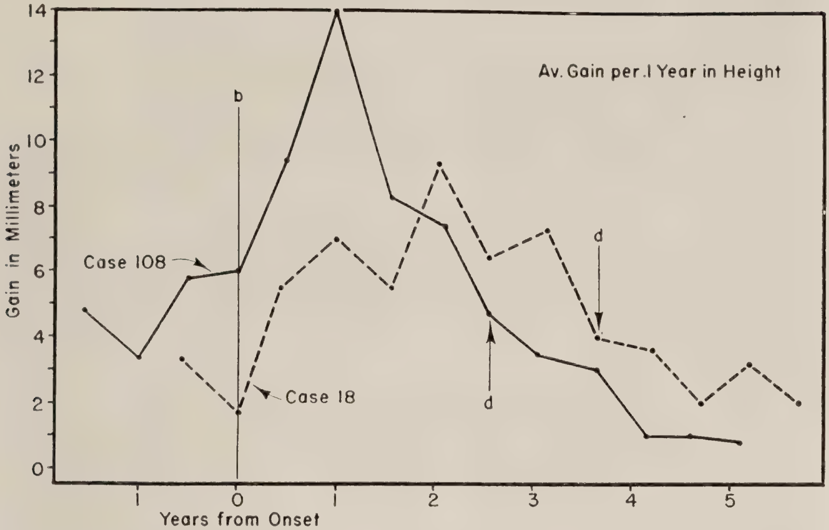


FIGURE 53a. Height growth curves for the two boys (Cases 18 and 108) whose photographs are shown in Figure 53b. Each made the same puberal gain.

Among the boys who made similar gains in different lengths of time there were two pairs of boys who were matched for height at both the onset and end of the puberal period, but the duration of the period varied. Data about these cases are summarized in Table 17, and illustrations are given in Figure 54.

Table 17 SIMILAR HEIGHT AT ONSET, SIMILAR GAIN, BUT DIFFERENT DURATION OF THE PUBERAL PERIOD

Case	*Height at Onset* Millimeters (b)	*Height at End* Millimeters (d)	*Gain* Millimeters (b–d)	*Duration Puberal Period* Years (b–d)
44	1468	1669	201	2.50
218	1463	1661	196	3.05
190	1513	1711	198	2.65
78	1519	1713	194	3.05

Relation of gain in height to age at onset. On the other hand, in contrast to the positive relation between amount of gain and duration, there seems to be a negative relation between the gain in height and the age at onset of the puberal growth period, as will be seen in the scatter diagram presented in Figure 55. The Pearson coefficient of correlation is —.483,

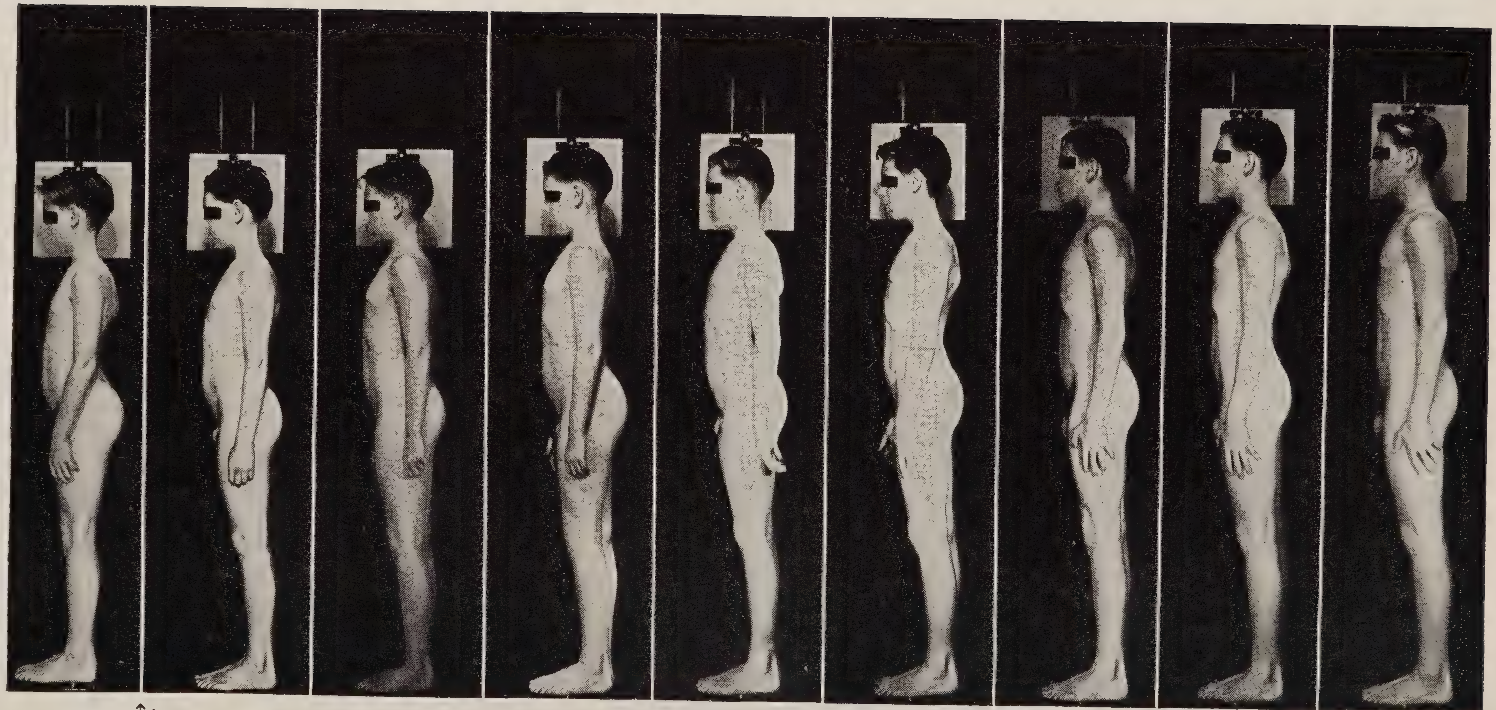
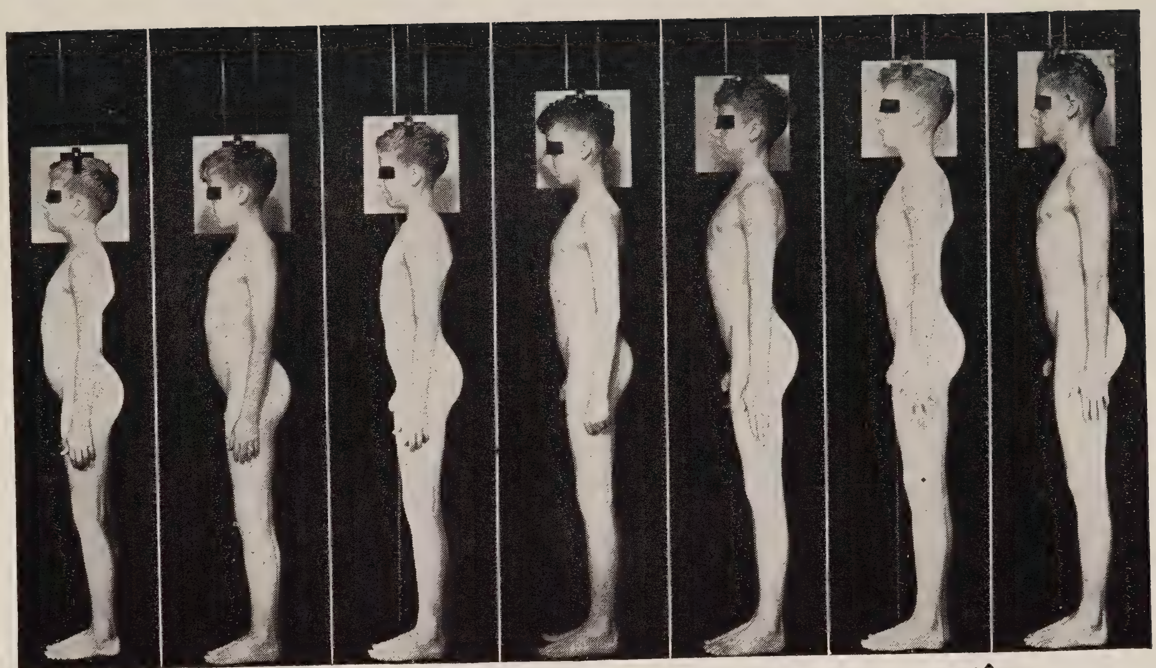


FIGURE 53b.
Case 18



Puberal onset ← Duration 2.55 years → Puberal end

Case 108

FIGURE 53b. Photographic series for two boys taken semi-annually during the puberal period. Case 18 gained 227 millimeters (8.94 inches) and Case 108 gained 228 millimeters (8.97 inches) in height during the period. Note that the duration of the puberal period was 1.10 years longer for Case 18 than for Case 108. (See growth curves in Figure 53a.)

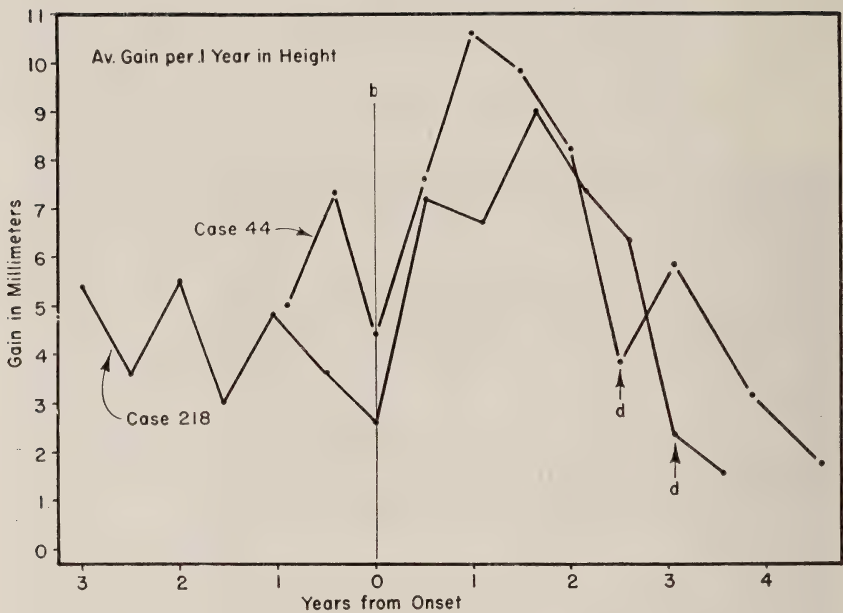


FIGURE 54. Height growth curves of two boys (Cases 44 and 218) who were about the same height at onset and who made similar gains during the puberal period. Case 44, however, made his gain in .55 year less than Case 218.

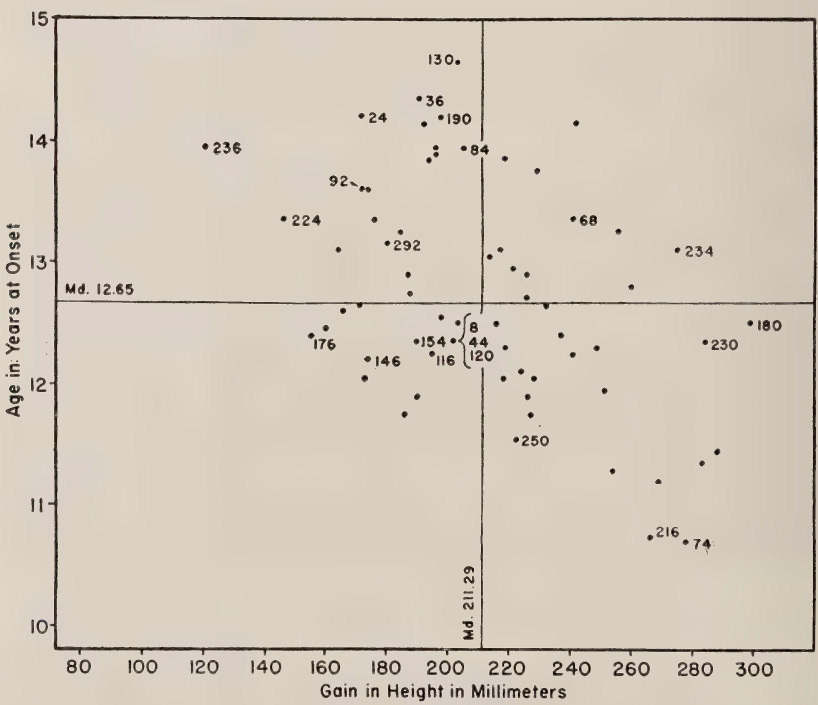


FIGURE 55. Relation of gain in height during the puberal growth period to age at onset. Coefficient of correlation —.483, P.E. ± .063.

P.E. ±.063. This indicates a tendency for early developers to gain more during the puberal growth period than late developers. Case 236 again is at the extreme, being among the oldest at the onset and the boy who gained the least during the period. Case 74 is just the opposite, being the youngest at onset and among those who gained the most during the period.

Here again we find cases with timing similar but amount of gain varying greatly. In Table 18 are listed five pairs of boys who were the same age at the onset of the puberal growth period in height, but who gained widely varying amounts during the total period. Figures 56a and b present two of these cases.

Table 18 SIMILAR AGE AT PUBERAL ONSET BUT VARYING PUBERAL GAIN

Case Number	*Age in Years at Onset*	*Amount of Gain in Height* Millimeters	*Amount of Gain in Height* Inches
176	12.40	155	6.10
230	12.35	284	11.18
292	13.15	181	7.1
234	13.10	275	10.8
224	13.35	146	5.8
68	13.35	241	9.5
66	13.65	126	4.96
92	13.60	172	6.77
236	13.95	121	4.8
84	13.95	205	8.1

We find cases, on the other hand, who made similar amounts of gain in height during the puberal growth period but who were markedly different in age (from two to three and one-half years' difference) at the onset of the period. In Table 19 are some examples of this taken from Figure 55. Figures 57a and b present two of the cases who gained identical amounts (7.5 inches) during the puberal growth period which began for Case 154 at 12.35 years and for Case 36 two years later.

Three boys, Cases 8, 44, and 120, began their puberal growth period at the same age (12.35 years), and each gained approximately 8 inches in height during the period (204, 201, and 200 millimeters, respectively).[8] Two of these boys (Cases 44 and 120) took the same amount of time to

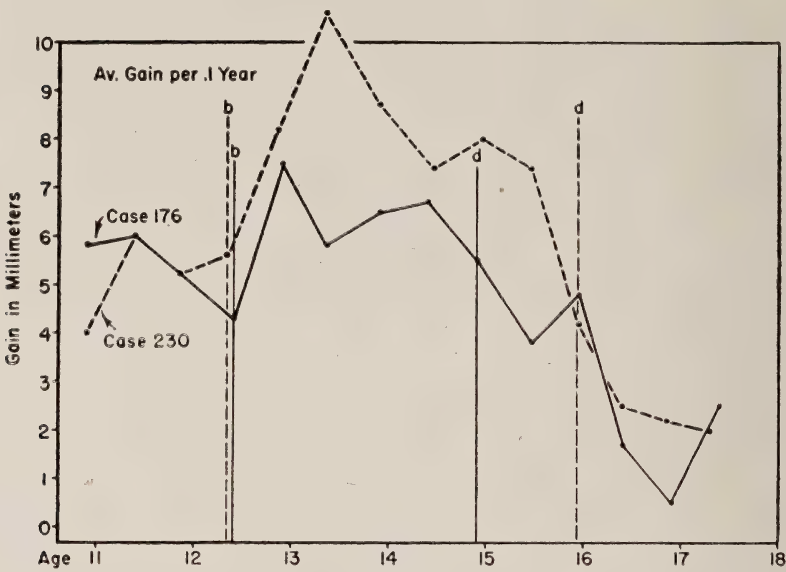
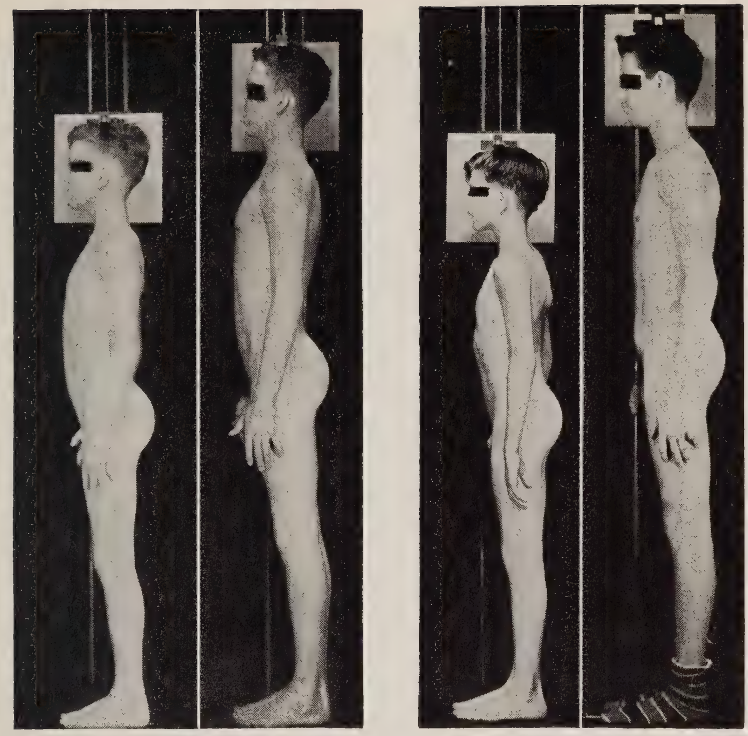


FIGURE 56a. Height growth curves of two boys (Cases 176 and 230) who began the puberal growth period at the same age (12.4 years). Case 176 gained 155 millimeters or 6.1 inches during the period, while Case 230 gained 284 millimeters or 11.2 inches. (See Table 18.)

Table 19 DIFFERENT PUBERAL ONSET AGE BUT SIMILAR PUBERAL GAIN

Case Number	*Age in Years at Onset*	*Amount of Gain in Height* Millimeters	*Amount of Gain in Height* Inches
74	10.70	278	10.94
234	13.10	275	10.83
116	12.25	195	7.68
190	14.20	198	7.79
154	12.35	190	7.5
36	14.35	190	7.5
146	12.20	174	6.9
24	14.20	172	6.8

accomplish this (2.50 and 2.55 years, respectively), though Case 120 was taller than Case 44 throughout. On the other hand, Case 8 took .4 of a year longer to gain the same amount even though he and Case 120 were



Case 176 **Case 230**

C.A. 12.40 14.90 12.35 15.95

FIGURE 56b. Photographs of two boys whose height growth charts are presented in Figure 56a. They began the puberal growth period at the same age, but Case 176 gained only 155 millimeters (6.10 inches), while Case 230 gained 284 millimeters (11.18 inches) during the period. (See Table 18.)

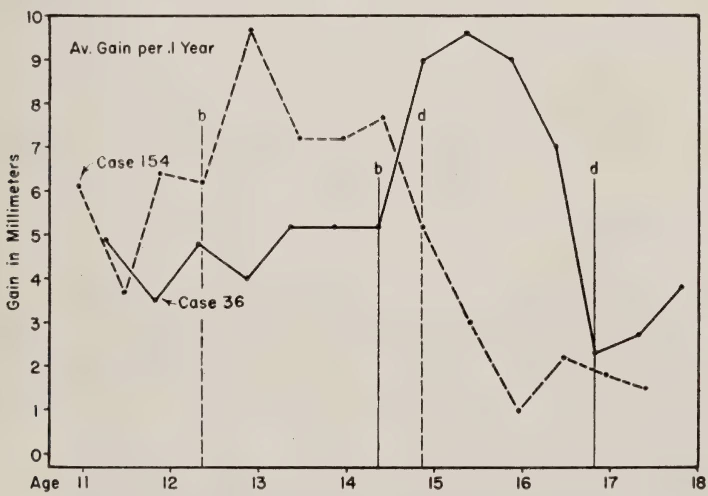
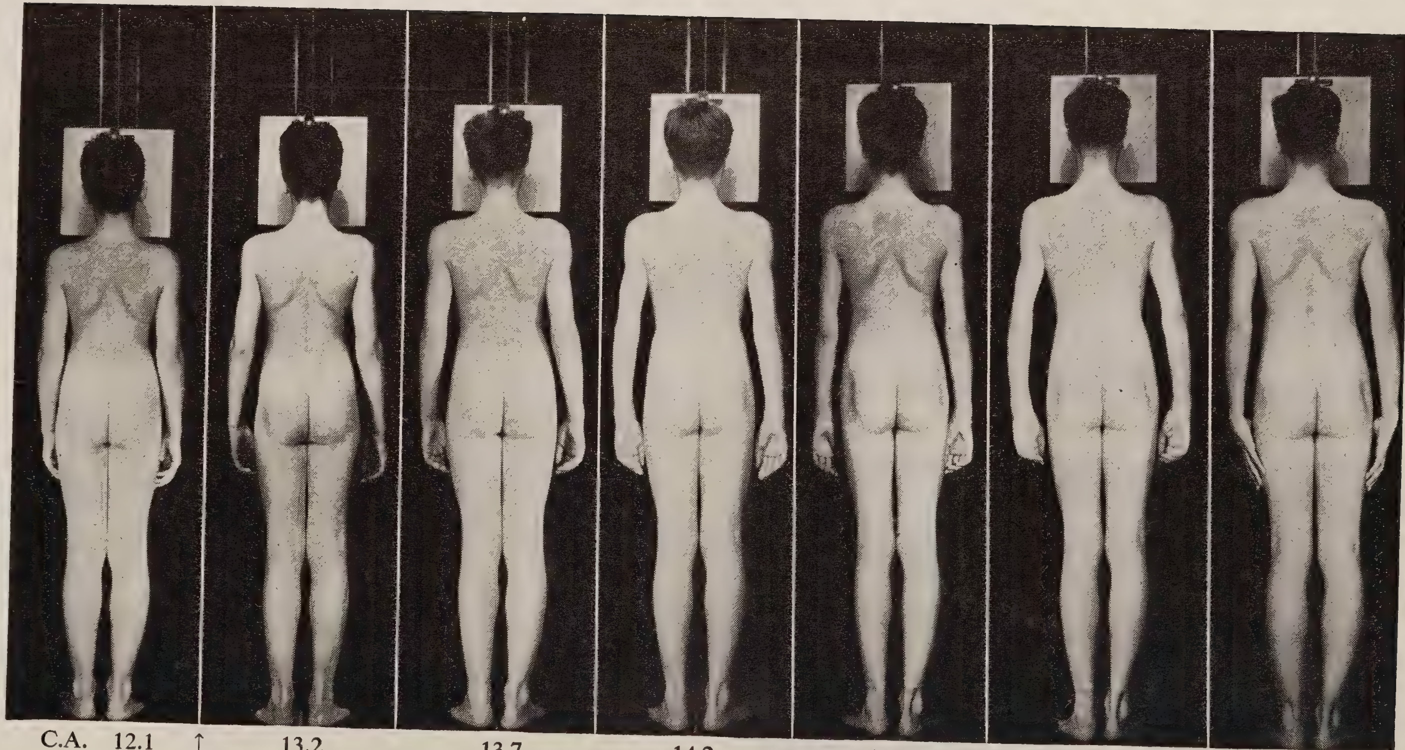
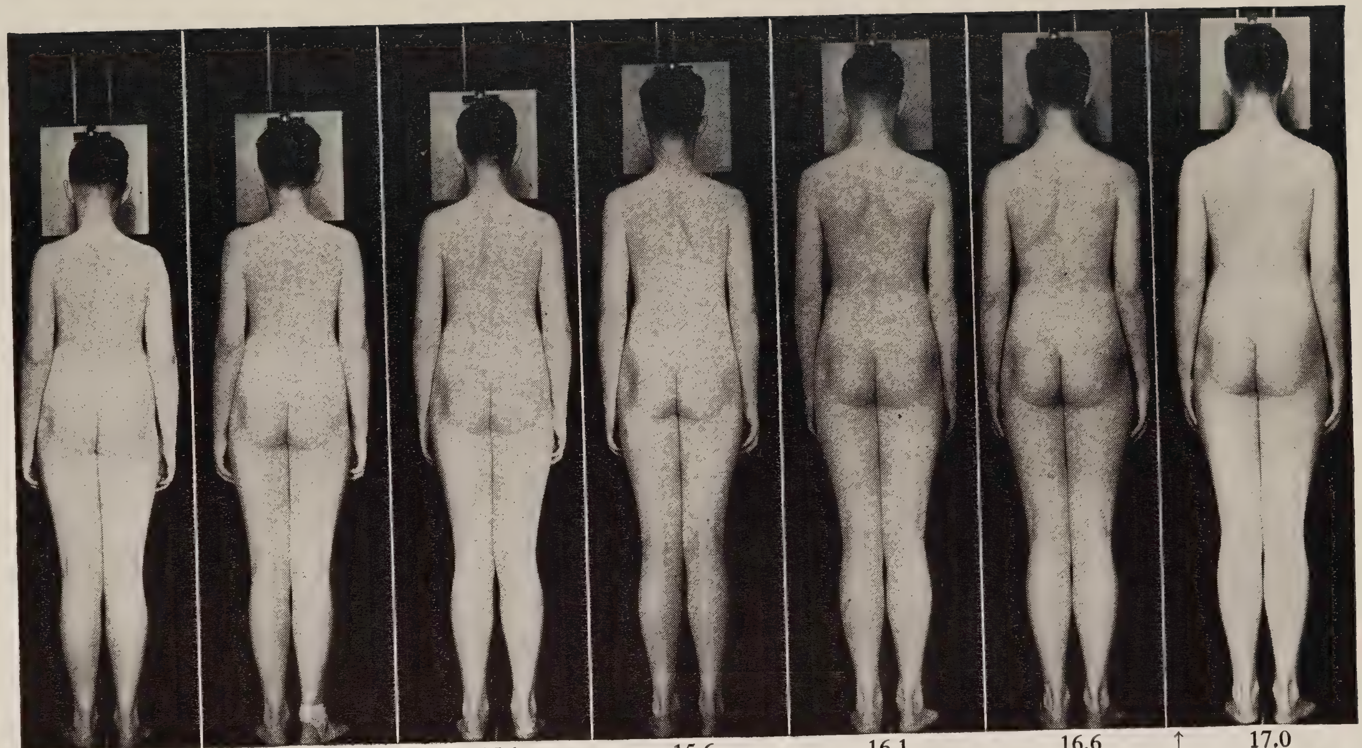


FIGURE 57a. Height growth curves of two boys (Cases 154 and 36) who gained identical amounts during the puberal growth period (190 millimeters or 7.5 inches) but with different timing and configuration.



C.A. 12.1 ↑ Puberal onset 13.2 13.7 14.2 14.2 14.6 ↑ Puberal end 15.1

FIGURE 57b. **Case 154**



C.A. 14.1 ↑ Puberal onset 14.6 15.1 15.6 16.1 16.6 ↑ Puberal end 17.0

Case 36

FIGURE 57b. Photographs of two boys (Cases 154 and 36) during the puberal period whose height curves are presented in Figure 57a. The timing of the puberal growth period is indicated by arrows at onset and end. Each gained 7.5 inches during that period.

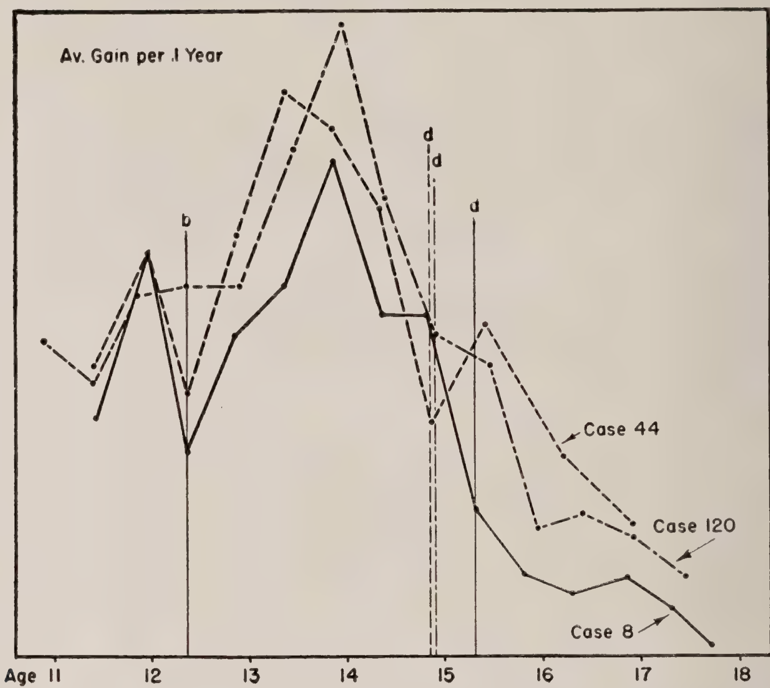


FIGURE 58a. Height growth curves of three boys (Cases 8, 44, and 120) who began the puberal growth period at the same age (12.35 years) and gained similar amounts in height during the puberal period (about 8 inches). (See Table 19.) Curves in this chart have been staggered in order to show contours more clearly.

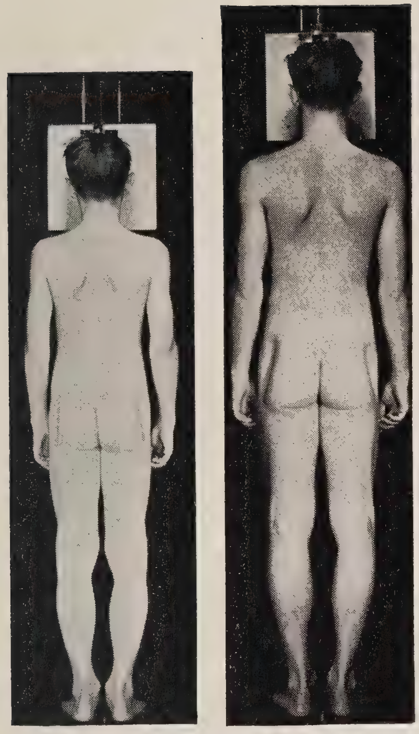
Table 20 SIMILAR ONSET AGE AND SIMILAR PUBERAL GAIN

Case	*Height at Onset* Millimeters (b)	*Height at End* Millimeters (d)	*Puberal Gain* (b–d)	*Age at Onset* Years (d)	*Age at End* Years (d)	*Duration* Year (b–d)
8	1,550	1,754	204 millimeters 8.03 inches	12.35	15.30	2.95
120	1,537	1,737	200 millimeters 7.87 inches	12.35	14.90	2.55
44	1,468	1,669	201 millimeters 7.91 inches	12.35	14.85	2.50

about the same height throughout. Data concerning these three boys are presented in Table 20 and Figures 58a and 58b.

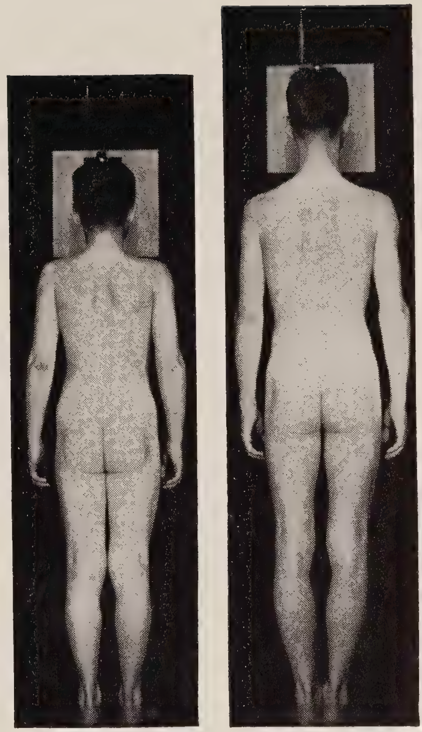
RATE OF PUBERAL GROWTH IN HEIGHT

An analysis was made of how rapidly the 67 boys grew in height during the puberal growth period irrespective of the duration of the period. This



Case 8

C.A. 12.35 15.30



Case 44

12.35 14.85

Case 120

12.35 14.90

FIGURE 58b. Photographs of three boys whose height curves are presented in Figure 58a, taken at onset and end of puberal growth period in height. Each boy made similar gains in height during the period (about two hundred millimeters or eight inches). (See Table 19.)

was done by dividing the puberal gain by the duration for each case. The distribution of the 67 cases is shown in Figure 59. The boys at the upper end of this distribution had dramatic spurts of growth during their puberal periods, while those at the lower end had moderate, undramatic increases in rate. Figure 60 illustrates the contrasts in the growth curves of two boys, one at the upper and one at the lower end of the distribution.

											244												
											190	250	230										
											86	216	96										
											62	52	74					108					
					236				212		40	154	120	150			146	292					
					176	218		206	164		180	136	116	304	134	144	106	80	100				
				294	54	78	168	34	130	72	166	30	36	112	84	184	88	50	234				
	224			58	18	60	220	8	68	242	64	10	32	44	82	66	92	24	26	104			110
mm	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8

FIGURE 59. Distribution of 67 boys by case numbers according to rate of growth in height (average gain per .1 year) during puberal period: mean, 7.67 millimeters; standard deviation, .918 millimeters; median, 7.73 millimeters; Q_1, 7.09 millimeters; Q_3, 8.57 millimeters.

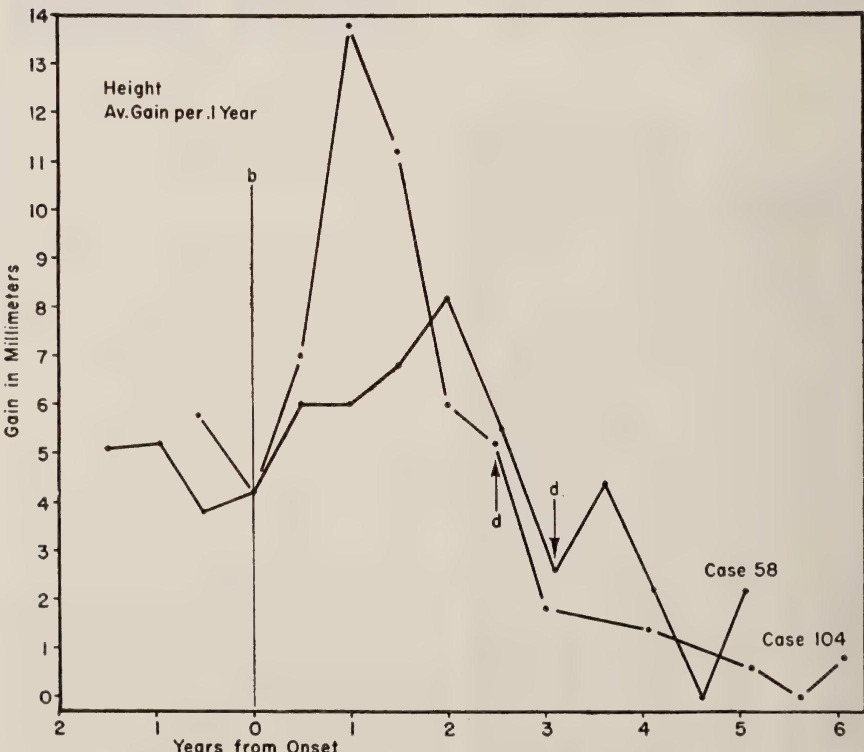


FIGURE 60. Contrasting height growth curves of two boys—one who had a dramatic spurt, and one who had a moderate growth during the puberal period (Cases 58 and 104).

The boy with the slowest rate gained at the rate of only 5.4 millimeters (.21 inch) per tenth of a year, while the boy with the most rapid rate gained at the rate of 9.88 millimeters (.39 inch). The mean rate was 7.67 millimeters with a standard deviation of .918 millimeter. The median rate was 7.73 millimeters with fifty per cent of the cases having a rate between 7.09 millimeters and 8.59 millimeters. The growth curve for Case 224, the boy with the lowest rate, is shown in Figure 91a, page 156, for Case 216, a boy with average rate, the growth curve is shown in Figure 61, page 107; for Case 110, the boy with the highest rate, the growth curve is shown in Figure 48a, page 88.

Relation of rate of puberal growth to onset age. There was only a very slight tendency for the boys who were early developers to grow at a more rapid rate than the late developers. The Pearson coefficient of correlation between age at onset and average gain in height per tenth of a year during puberal period was −.204, P.E. ±.079. In fact, there were late developers who grew rapidly and early developers who grew slowly. The three boys with the most rapid rate were below the mean in age at onset; the three boys with the slowest rate were above the mean in age at onset. But outside of these extremes one finds great variation. In Figure 61 are the

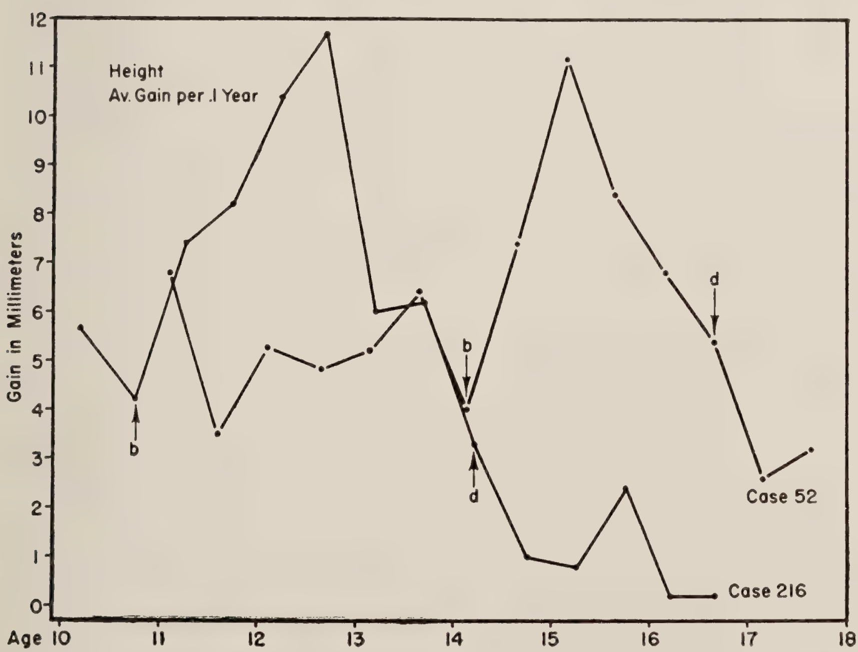


FIGURE 61. Height curves of two boys where the puberal growth rate was the same (7.7 millimeters per tenth of a year). Case 216 was an early developer, Case 52 a later developer.

curves of two boys whose puberal height growth rate was 7.7 millimeters per tenth of a year; Case 216 was an early developer, Case 52 a late developer.

Relation of rate of puberal growth to height at puberal onset. There is no relation between a boy's height at onset and the rate at which he will grow during the puberal period. The Pearson coefficient of correlation was $-.094$ with a probable error of $\pm.082$. A tall boy may have a rapid or slow rate; the same is true for a short boy. If we study the ten per cent tallest boys we find that their puberal rates vary from the lowest to the next to highest rates. Their ages at onset vary from the youngest to the upper quartile. The data for these seven cases are given in Table 21.

An analysis of the ten per cent shortest boys shows a somewhat different picture. They vary less in both rate and in onset age than the tall boys. There was only one boy below the mean in age and none under 7.55 millimeters in growth rate per tenth of a year. (See Table 21.)

Table 21 PUBERAL RATE IN HEIGHT GROWTH IN RELATION TO HEIGHT AND AGE AT ONSET

10 Per Cent Tallest at Onset Case Number	*Height Growth Puberal Rate* millimeters per .1 year	*Age at Onset* Years
236	6.2	13.95
74	7.9	10.70
224	5.5	13.35
134	8.2	13.35
32	7.8	12.05
104	9.2	11.75
168	6.7	12.25
Mean for 67 Cases	7.67	12.76
10 Per Cent Shortest at Onset Case Number		
116	7.8	12.25
62	7.5	12.90
40	7.5	12.75
304	8.0	13.10
92	8.6	13.60
10	7.6	12.95
60	6.4	12.90

COMPARISON OF PUBERAL WITH PREPUBERAL AND POSTPUBERAL HEIGHT GROWTH

A comparison of height growth during the puberal period with growth immediately preceding and following it emphasizes some of the unique

characteristics of the puberal growth phenomenon. The mean gain in height for the 67 boys during the puberal period (b to d) was 212.15 mm (8.36 inches). For the prepuberal period (b — 3 to b) the mean gain was 56.99 mm (2.23 inches); for the postpuberal period (d to d + 3) it was 41.22 mm (1.62 inches). Thus it can be seen that the puberal gain was more than twice the combined gain of the adjacent periods.

However, the mean duration of the puberal period (2.81 years) was only slightly longer than the combined durations of the prepuberal and postpuberal periods (2.50 years). Thus the mean rate of growth during the puberal period was 7.55 mm per .1 year while the mean rate during the prepuberal period and postpuberal periods combined was 3.91 mm per .1 year.

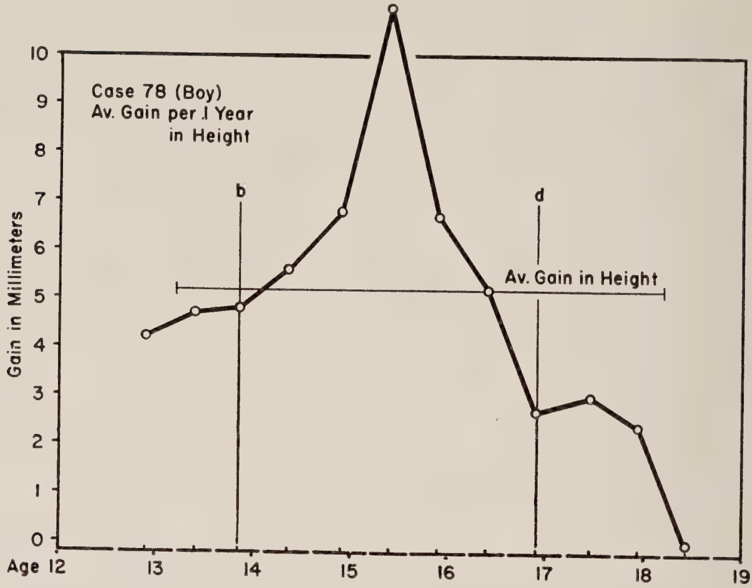
Comparison also may be made in terms of the percentage gain in height during each of these periods. Data were avalaible for 51 cases for this analysis. From the beginning of the prepuberal period (b — 3) to the end of the postpuberal period (d + 3) the mean percentage gain in height was 20.33; standard deviation, 2.76. During the prepuberal period the gain in height was 4.31 per cent; standard deviation, .57; during the puberal period the gain was 13.59 per cent; standard deviation, 2.59; during the postpuberal period the gain was 2.43 per cent; standard deviation, .89.

CONFIGURATION OF THE GROWTH PROFILE FOR HEIGHT

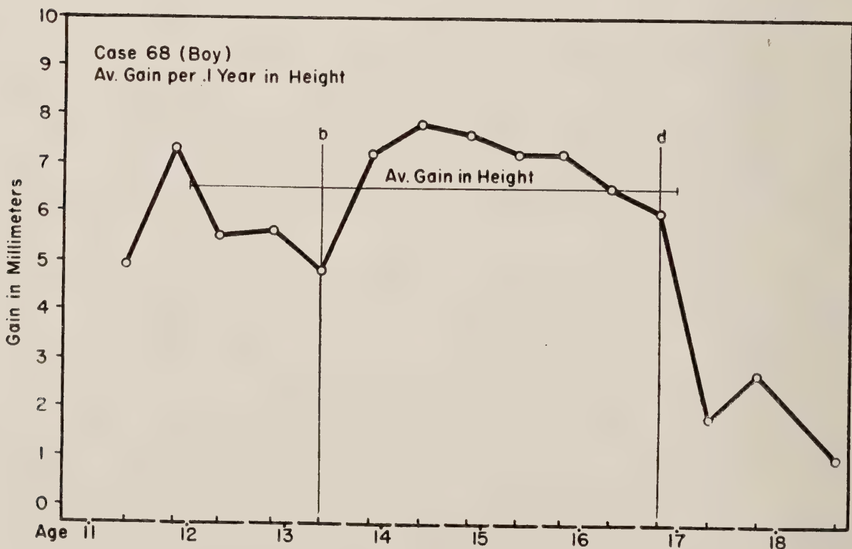
In this study we emphasize the usefulness of analyzing growth data in terms of *rate* or *velocity* of growth through time. We are convinced that this method of presentation brings out the similarities and dissimilarities in the growth process as among individuals, and that it brings out, also, likenesses and differences of pattern as among the several aspects of growth in the same individual.

In the preceding sections of this chapter we have analyzed quantitative differences of timing and height magnitude at certain developmental points. In this section we will describe some of the other configuration characteristics of the height growth profiles during adolescence.

In looking over more than one hundred growth velocity profiles for height we notice at once that for one or more years immediately preceding the onset (b) of the puberal period the trend of the profile lines is upward in almost every case. Following the close (d) of the puberal period the trend of the profile is downward in every case. During the prepuberal phase there is usually a series of peaks and dips, and these often represent marked differences of growth rate for successive half year periods. During the postpuberal phase the peaks are relatively low, the dips frequently fall

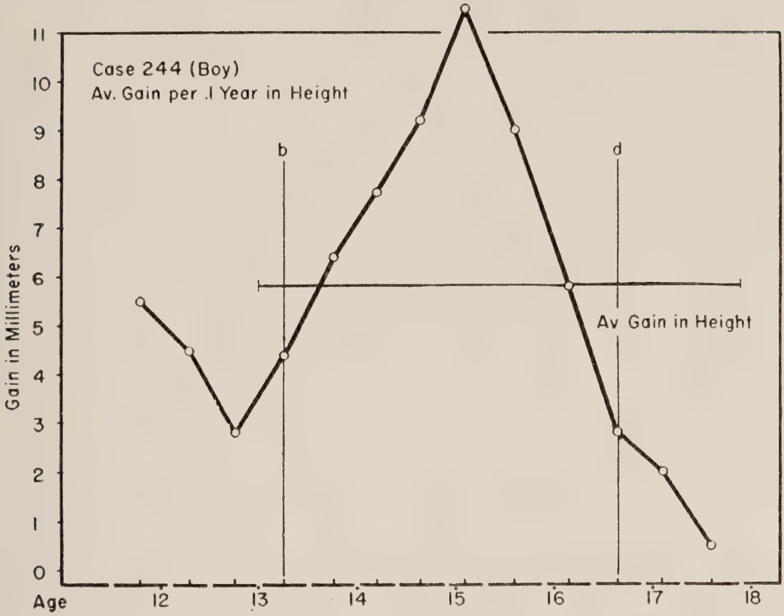


a

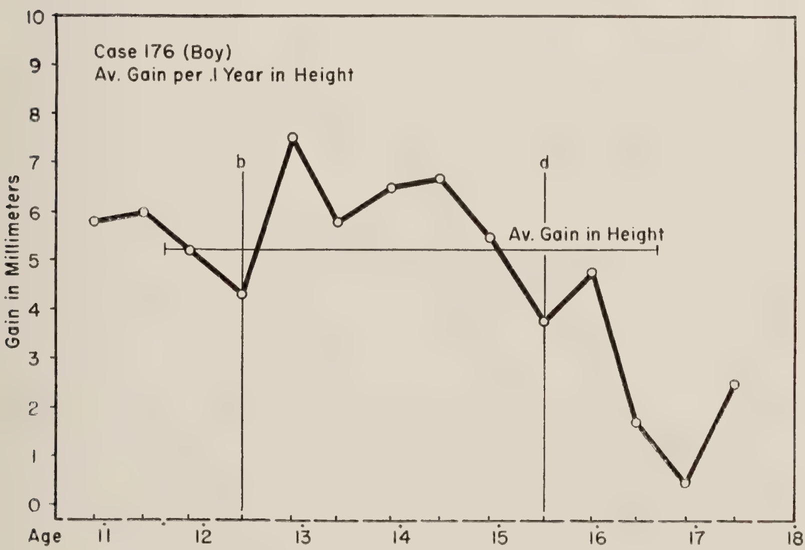


b

FIGURE 62a and b. Growth curves of height of two boys representing contrasts in configuration. In Case 78 the curve rises rapidly to the apex and immediately falls. In Case 68 the curve is maintained close to the apex rate for about three years.



a



b

FIGURE 63a and b. Height growth curves of two boys representing contrasts in configuration. In Case 244 the apex is more than twice the average gain in height for the five year period. In Case 176 the apex is less than one and one-half times the average.

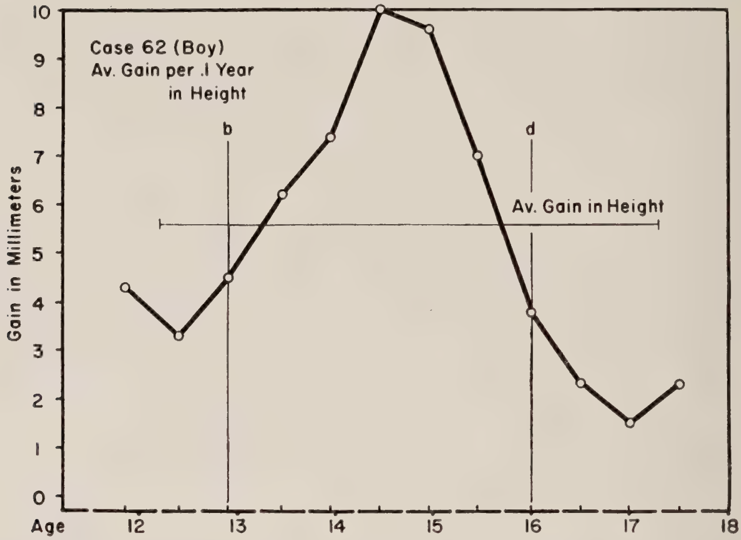


FIGURE 64a. Height growth curve of a boy (Case 62) illustrating a growth curve with uninterrupted acceleration to and deceleration from the apex. Of the 67 cases, 61.13 per cent showed similar configuration.

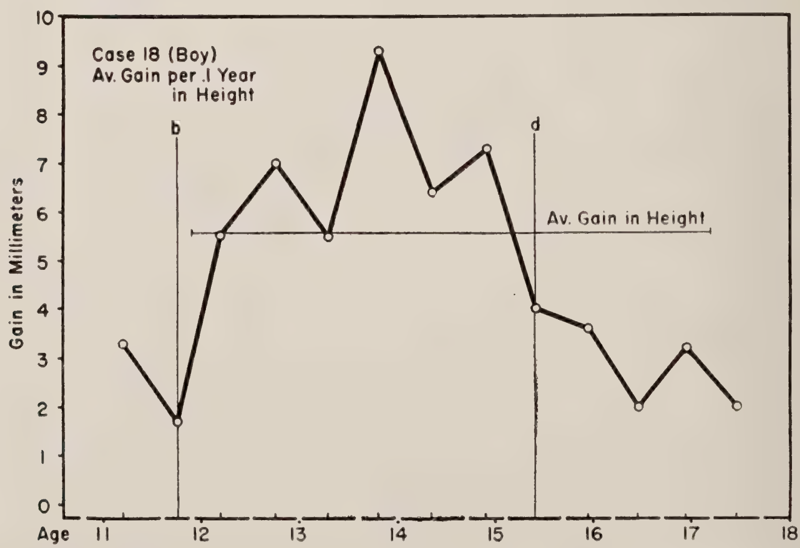


FIGURE 64b. Height growth curve of a boy (Case 18) with acceleration and deceleration of the curve interrupted for short periods. Only 4.48 per cent of the 67 cases showed similar configuration.

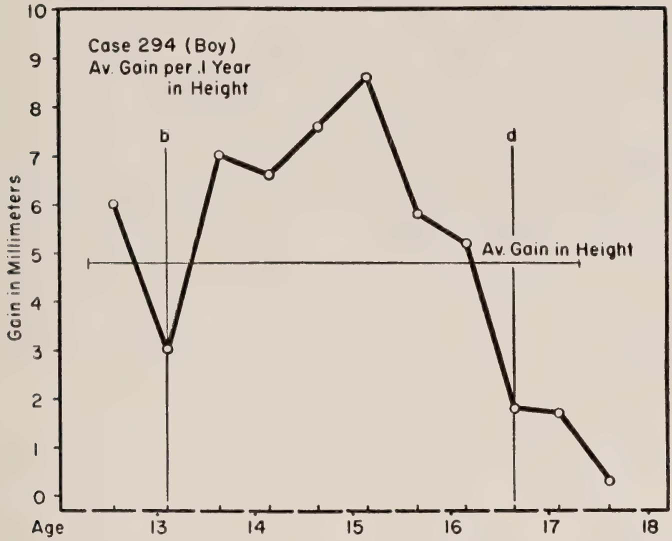


FIGURE 64c. Height growth curve of a boy (Case 294) where the acceleration to the apex was interrupted by a short period of deceleration. Of the 67 cases 14.92 per cent showed similar configuration.

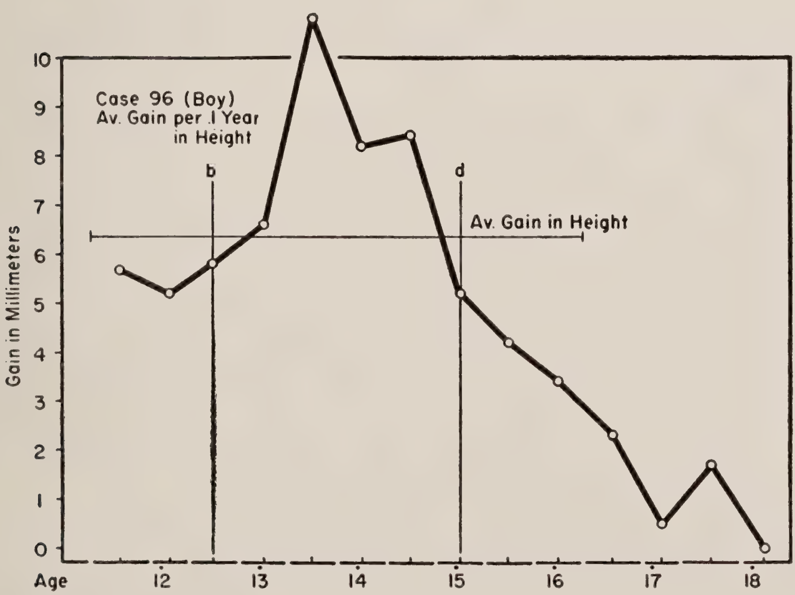


FIGURE 64d. Height growth curve of a boy (Case 96) where the deceleration from the apex was interrupted by a short period of acceleration. Of the 67 cases 19.4 per cent showed similar configuration.

to the zero base line, and there is less tendency toward alternation of acceleration and deceleration every half year.

During the puberal period (b to d), although each profile is unique in its configuration, the general pattern usually includes a profile line which rises for at least a year, an apex flexion which may be sharp or gradual, and, finally, a profile line which falls precipitously. Profiles which illustrate the wide variation among individuals are shown in Figures 62a and b.

In some cases the rate of growth at the apex is more than twice the average rate for the five year period in which it is centrally located (Case 244 in Figure 63a). In other cases the rate of growth at the apex is less than one and one-half times the five year average. (See Case 176 in Figure 63b.)

In 41 cases (61.13 per cent) acceleration from onset of the puberal growth period to the apex was uninterrupted, and deceleration from the apex to the end of the puberal growth period in height was also uninterrupted. (See Case 62 in Figure 64a.) In three cases acceleration to the apex was interrupted by a short period of deceleration, and deceleration from the apex was interrupted by a short period of acceleration. (See Case 18 in Figure 64b.)

In ten cases acceleration to the apex was interrupted by a short period of deceleration, but deceleration from the apex to the end of the puberal growth period was uninterrupted. (See Case 294, Figure 64c.) In thirteen cases acceleration to the apex was uninterrupted, but deceleration from the apex was interrupted by a short period of acceleration. (See Case 96 in Figure 64c.)

Major peaks and dips. The profiles of the velocity of growth for every individual and for every measurement or rating tend, with but very few exceptions, to show changes in direction from each half year period to the next. Sometimes these changes represent differences in rate of acceleration, sometimes differences in rate of deceleration, sometimes a change from acceleration to deceleration, and sometimes a change from deceleration to acceleration. Only very rarely is the velocity the same in two successive periods or the rate of acceleration or deceleration the same for two successive periods. By inspection, it is often, but not always, easy to distinguish between the major inflexions which outline the general pattern and the minor inflexions which do not determine that pattern.

In an effort to translate visual judgment into a more precise description we have defined each pattern in terms of major peaks and major dips, tabulated the frequency with which they occur, and analyzed their position relative to the puberal growth period for height.

For this purpose we have defined a major peak as a point in the profile

which lies above the average rate for the five year period, which is preceded by acceleration from a point below the five year average, and which is followed by deceleration to a point below that average without interruption by any other major peak. A major dip is defined as a point representing zero velocity or a negative velocity (in weight, for example) which is preceded by deceleration from a point above the five year average, and which is followed by acceleration to a point above that average without interruption by any other major dip.

In an effort partially to describe the configuration of the height growth profiles for our 67 boys in quantitative language, we have tabulated the number of major peaks and major dips for each case.[9] During the adolescent years which our data cover, the range for number of major height peaks among our sample was from 1 to 3 and the mean 1.61. There were 31 of the 67 profiles (46.27 per cent) in which the puberal apex was the only major peak; in 31 profiles there was one major peak in addition to the puberal apex; in 5 profiles (7.46 per cent) there were two additional major peaks.

Of the 67 profiles only 1 (Case 166) showed a major dip, as defined. This dip occurred in the prepuberal period 1.45 years prior to the puberal onset (b).

SUMMARY

The measurements in height of the 67 boys were compared at four developmental points; during the prepuberal period, at the onset and end of the puberal period, and during the postpuberal period. The difference between the tallest and shortest boy at each point increased from 276 millimeters (10.52 inches) at the prepuberal point to 284 millimeters (11.18 inches) at onset and 352 millimeters (13.86 inches) at end of the puberal period. The range decreased slightly during the postpuberal period to 344 millimeters (13.55 inches) but was still 28.8 per cent greater than during the prepuberal period. One boy was consistently the shortest at each developmental point; one boy was the tallest at three developmental points. There was a high correlation between the height of boys at the onset and end of the puberal period (r. .819 P.E. $\pm$.027).

At the beginning of the puberal growth period there was a slight tendency for the younger boys to be shorter than the older boys. There was also a slight tendency for the boys who were younger at puberal onset to be taller during the postpuberal period. However, the individual variations were so great that the chronological age of a boy at the onset of the puberal period could not be used as a basis for predicting his mature height with any degree of certainty.

The boys varied in amount of gain in height during the puberal period from 121 millimeters (4.76 inches) to 299 millimeters (11.77 inches). Percentage gains and actual gains had a high correlation (.973 ± .004). In general, the longer the duration of the puberal period the greater the gain in height, although there were individual cases who differed markedly from this pattern, some having slight growth over a long period, while others had rapid growth during a relatively short period.

The mean duration of the puberal period was greater than the sum of the mean durations of the prepuberal and postpuberal periods (2.50 years). The mean gain in height during the puberal period (212.15 millimeters, or 8.36 inches) was slightly more than *twice* as great as the sum of mean gains during the prepuberal and postpuberal periods (97.81 millimeters, or 3.85 inches). The mean percentage gain from the beginning of the prepuberal period to the end of the postpuberal period was 20.33, of which 13.59 percentage gain occurred during the puberal period.

There was a tendency for early developers to make greater puberal gains than late developers (r. —.483 ±.063). Some, though by no means all, of the late developers made a higher percentage of their final height before the puberal onset than some of the early developers.

The boy with the most rapid rate of puberal growth in height grew almost twice as fast as the boy with the slowest rate; the mean rate was 7.67 millimeters (.302 inch per .1 year). Height at onset showed no correlation with rate of puberal growth, and age at onset showed very slight relation.

Each individual's profile configuration for puberal height growth was unique. The general profile pattern usually included a rise for at least a year, a sharp or gradual apex flexion, followed by a precipitous fall in the line. Almost two thirds of the cases (61.13 per cent) had profile curves which accelerated to and decelerated from the apex without interruption. The others showed a variety of short-period fluctuations which interrupted the prevailing pattern of the curve.

During the adolescent years covered by our data, 46.27 per cent of the boys had only one major peak in height growth (the puberal apex), while a similar percentage had one major peak in addition to the puberal apex. Only one case showed a major dip—a decrease to the zero base line between periods of above-average growth.

FOOTNOTES FOR CHAPTER V

[1] For twelve cases the data did not include Point b — 3, and for four cases the data did not include Point d + 3. For eight cases measurements at b — 2 and for four cases measurements at b — 1 were used. For three cases measurements at d + 2 and for one case measurements at d + 1 were used.

[2] Measurements for each boy are shown in Appendix G.

[3] Height was measured to the nearest millimeter and all discussion is presented in millimeters. For those not used to thinking in the metric system, ten millimeters, or one centimeter, equal .3937 inch. In the text the equivalent to the nearest hundredth of an inch is given in some instances.

[4] This is eliminating Case 74, the tallest boy, because his measurements were not available until b — 1.

[5] Of these sixteen supplementary cases Point b was statistically computed for seven cases and estimated for nine.

[6] Case 236 was among the twenty per cent oldest in chronological age at the onset of the puberal growth period.

[7] See discussion in Chapter XV.

[8] Translated into inches, Case 8 gained 8 inches, Case 44 gained 7.9 inches, and Case 120 gained 7.87 inches.

[9] The complete tabulation of major peaks and dips in the profiles for height, stem length, leg length, shoulder width, hip width, thigh circumference, weight, and muscular strength will be found in Appendix H.

Chapter VI GROWTH IN STEM LENGTH AND LEG LENGTH DURING ADOLESCENCE

HEIGHT growth is a composite made up mainly of the longitudinal growth of bones of legs, trunk, neck, and head. In the Adolescent Study we measured not only height but also stem length.[1] By subtracting stem length from height we have a derived measurement for leg length.

Section A GROWTH IN STEM LENGTH

In any study of human growth stem length ranks as one of the important measurements. Relatively rapid growth in stem length is one of the characteristics of the adolescent period. During this period changes in stem length modify body proportions from the short-waisted, long-legged ratio typical in late childhood to the final adult ratio. Moreover, growth in stem length represents growth of the vital organs contained in the thoracic, abdominal, and pelvic cavities. Stem length is made up of head height, neck length, and trunk length, but by the onset of the adolescent period growth in head height is almost complete, and neck growth comprises but a small fraction of stem length increase.

Taken in relation to the already established developmental points for height, the analysis of stem length growth gives valuable information not only concerning changes in body proportions but also about the rhythmic pattern which seems to dominate many aspects of growth during the adolescent period.

In this section we will analyze and discuss the stem length measurements for our sample in relation to the puberal growth period for height, the increases in stem length, the changes that occur in the stem length/height ratio, and the configuration of the stem length profiles.[2]

STEM LENGTH MEASUREMENTS AT DEVELOPMENTAL POINTS

The distributions of the 67 boys according to stem length measurements at the four developmental points during adolescence are shown in Figures 65a, b, c, and d. Analyses of the measurements for the group are given in Table 22.

During the prepuberal period (at Point b — 3) the sample ranged in stem length from 681 millimeters (26.81 inches) to 818 millimeters

Table 22 STEM LENGTH MEASUREMENTS DURING ADOLESCENCE FOR 67 BOYS

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	Q_1	*Median*	Q_3	*Coefficient of Variation*
A. In Millimeters							
Prepuberal (b − 3)	681–818	752.75	27.60	735.00	751.76	776.10	3.67
Onset of puberal growth period (b)	705–823	774.61	28.20	758.09	773.50	794.25	3.67
End of puberal growth period (d)	806–963	886.85	32.20	867.91	889.05	907.00	3.63
Postpuberal (d + 3)*	837–985	915.57	32.80	895.50	917.05	939.00	3.58
Puberal gain (b–d)	55–146	112.24	20.37	101.62	113.12	128.65	
B. In Inches							
Prepuberal (b − 3)	26.81–32.20	29.64	1.09	28.94	29.60	30.56	
Onset of puberal growth period (b)	27.76–32.40	30.51	1.11	29.84	30.46	31.27	
End of puberal growth period (d)	31.74–37.92	34.92	1.28	34.14	35.00	35.71	
Postpuberal (d + 3)*	32.96–38.78	36.05	1.29	35.26	36.11	36.96	
Puberal gain (b–d)	2.16–5.75	4.41	.80	4.01	4.46	5.06	

* Sixty-six cases at the postpuberal point (d + 3).

(32.20 inches), a difference of 137 millimeters (5.4 inches). The mean of the measurements was 752.75 millimeters (29.64 inches) with a S.D. of 27.60 millimeters (1.09 inches).

At the onset of the puberal period (b) the range for 67 boys was from 705 millimeters (27.76 inches) to 823 millimeters (32.40 inches), a difference of 118 millimeters (4.64 inches). As can be seen, there was an overlapping of 89.55 per cent of the cases in the distributions at the pre-puberal point and the puberal onset. This is an indication of the relatively small amount of growth which is made in stem length during the pre-puberal period.

Millimeters	Case numbers
680	40, 62
690	
700	212, 92
710	242, 10, 304
720	206, 180, 88, 190, 60, 108, 116
730	166, 84, 50, 78, 24
740	64, 106, 72, 100, 36, 130, 110, 218, 164, 82
750	216, 34, 220, 146, 120, 144, 26, 18, 184, 30, 80, 154, 44
760	292, 96, 294, 136
770	52, 54, 8, 86, 68
780	168, 112, 244, 150, 134, 58
790	224, 236, 250, 176, 66, 234, 32
800	104
810	74

FIGURE 65a. Distribution of 67 boys by case numbers according to stem length measurements during the prepuberal period (b — 3): mean, 752.75 millimeters; standard deviation, 27.60 millimeters; median, 751.74 millimeters; Q_1, 735.00 millimeters; Q_3, 776.10 millimeters.

Millimeters	Case numbers
700	62, 40
710	
720	304
730	92, 10, 212
740	116, 206, 180, 242, 108
750	218, 26, 164, 88, 60, 230, 190
760	80, 18, 154, 82, 130, 84, 24, 50, 166, 78, 64
770	136, 184, 86, 44, 30, 294, 216, 72, 220, 100, 144, 36
780	150, 120, 106, 34, 110, 146
790	68, 244, 250, 8, 96, 58, 292
800	52, 54
810	234, 236, 104, 224, 134, 32
820	74, 66, 176, 168, 112

FIGURE 65b. Distribution of 67 boys by case numbers according to stem length measurements at onset of puberal period for height (b): mean, 774.61 millimeters; standard deviation, 28.20 millimeters; median, 773.50 millimeters; Q_1, 758.09 millimeters; Q_3, 794.25 millimeters.

Millimeters	Case numbers
800	40
810	
820	62, 304, 92, 242
830	60
840	
850	10, 206, 88, 190, 24, 212
860	154, 116, 146, 218, 78
870	58, 220, 86, 66, 72, 108, 130
880	120, 236, 106, 50, 180, 110, 84, 34, 18, 64
890	80, 224, 36, 44, 230, 166, 96, 292, 164, 30, 144
900	82, 250, 104, 126, 136, 134, 112, 54, 294, 100, 176
910	216, 8, 52, 184
920	150
930	32, 68
940	244
950	74
960	234, 168

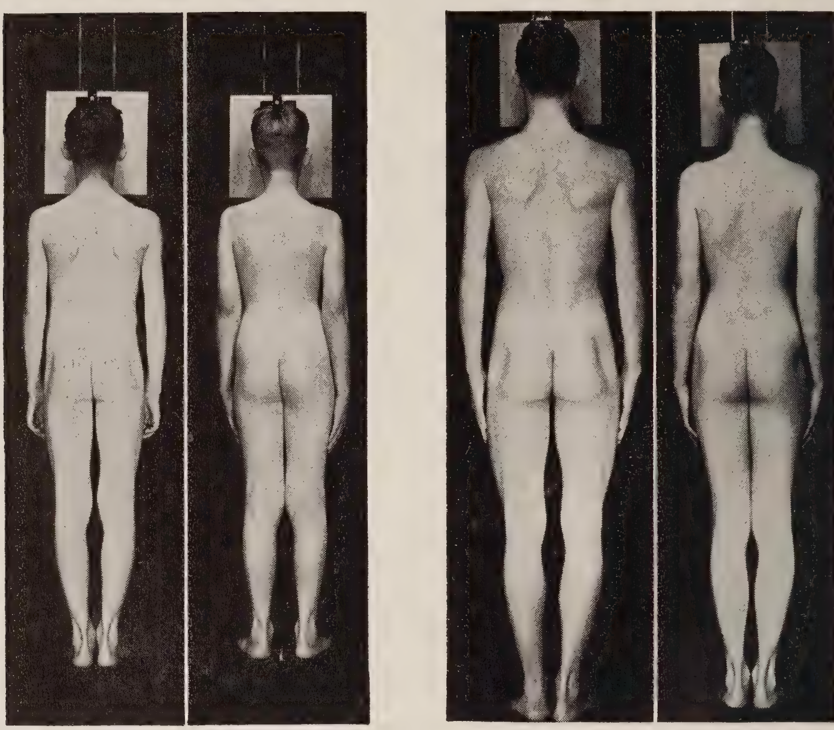
FIGURE 65c. Distribution of 67 boys by case numbers according to stem length measurements at end of the puberal growth period for height (d): mean, 886.85 millimeters; standard deviation, 32.20 millimeters; median, 889.05 millimeters; Q_1, 867.91 millimeters; Q_3, 907.00 millimeters.

Millimeters	Case numbers
830	40
840	
850	62, 92
860	242, 304, 212
870	218, 60, 190
880	206, 130, 24
890	154, 116, 220, 86, 10, 146, 78
900	166, 36, 180, 88, 72, 84, 66, 236, 18, 108
910	50, 230, 106, 58, 224, 34, 64, 294
920	134, 96, 110, 164, 54, 120, 30
930	144, 250, 292, 52, 26, 80, 136
940	104, 176, 112, 44, 82, 184, 216, 8
950	244, 150, 100, 68
960	
970	234
980	74, 168, 32

FIGURE 65d. Distribution of 67 boys by case numbers according to stem length measurements during postpuberal period for height (d + 3): mean, 915.57 millimeters; standard deviation, 32.80 millimeters; median, 917.05 millimeters; Q_1, 895.50 millimeters; Q_3, 939.00 millimeters.

At the end of the puberal period (d) the range was 806 millimeters to 963 millimeters (31.74 inches to 37.92 inches), a difference of 157 millimeters (6.18 inches). The mean had increased to 886.85 millimeters (34.92 inches) with a S.D. of 32.20 millimeters (1.28 inches). The overlapping of cases between the onset and end of the puberal period was only 19.40 per cent. This is a period of relatively high velocity in stem length growth. This will be discussed later in greater detail.

At the postpuberal point (d + 3) the range was from 837 millimeters to 985 millimeters (32.96 inches to 38.78 inches), a difference of 148 millimeters (5.82 inches). Between the end of the puberal period and the postpuberal point there was an overlapping of 86.57 per cent of the 66 cases, an indication of the relatively slow growth in stem length after the end of the puberal period.



Case 168 **Case 58** **Case 168** **Case 58**

C.A. 11.0 12.1 17.1 17.6

Prepuberal period Postpuberal period

(Photographs matched at gluteal fold)

FIGURE 66. Two boys whose growth in stem length during adolescence differed in consistency of relation to the group. Case 168 was consistently long-stemmed from Point b — 3 in the prepuberal period to Point d + 3 in the postpuberal period. Case 58 ranked among the long-stemmed boys at b — 3, but at d + 3 his stem length was less than the group mean. Growth curves for these boys will be found on the following pages: for Case 168, Figures 34a and 185c, pages 65 and 402; for Case 58, Figure 102b, page 176.

The same boy (Case 40) had the shortest stem length at all four points. Case 116, who shared with Case 40 the unwelcome distinction of least height, had a stem length which exceeded that of at least seven of his fellows at all four points. Of the seven boys who made up the lowest ten per cent at b — 3, five remained in the lowest ten per cent at each of the three subsequent developmental points (b, d, and d + 3); one fell outside this group at b but within it at d and d + 3; one remained in the group at b but was not included at d or d + 3.

At the other end of the distribution, Case 74 had the greatest stem length at b — 3, b, and d + 3 and was the only case which fell in the

upper ten per cent at all four determinations. Cases 168 and 234 appeared in that group at b, d, and d + 3. Of the other cases involved, six were among the upper ten per cent at two of the four determinations, while five appeared but once in that group.

For our sample it would appear that there was a strong tendency for boys who were short-stemmed during the prepuberal period to remain consistently short-stemmed through the puberal and postpuberal periods; among the long-stemmed boys the positional pattern was much less consistent.

Figure 66 shows photographs of two boys at the prepuberal point (b — 3) and at the postpuberal point (d + 3) whose growth in stem length followed different patterns during adolescence.

The variability of the group was practically the same at each of the four points, as shown by the coefficient of variability. The 67 boys were less variable in stem length at every developmental point than they were in total height. The difference was greatest during the prepuberal period and became less at each succeeding point. (See Table 23.)

Table 23 COMPARISON OF VARIABILITY IN HEIGHT AND IN STEM LENGTH—67 BOYS

Developmental Point	*Coefficient of Variation*	
	Height	Stem Length
Prepuberal (b − 3)	4.30	3.67
Puberal onset (b)	4.02	3.67
Puberal end (d)	3.83	3.63
Postpuberal (d + 3)*	3.65	3.58

* Sixty-six cases.

PUBERAL GAIN IN STEM LENGTH

The amount of gain in stem length during the puberal period varied from 55 millimeters to 146 millimeters (2.16 inches to 5.75 inches) with a mean of 112.24 millimeters (4.41 inches). The range is somewhat misleading as fifty per cent of the cases were between 101.62 millimeters and 128.65 millimeters (4 inches and 5.06 inches). The boy who gained least in stem length was in the upper quartile in stem length measurements at the onset but was below the mean at the end of the puberal period and kept this position at d + 3 in the postpuberal period. The distribution of the 67 boys according to puberal gain in stem length is given in Figure 67.

Relation of gain in stem length to gain in height. There was a Pearson coefficient of correlation between puberal gains in stem length and in height of .894 with P.E. ±.016. The scatter diagram in Figure 68 shows

Millimeters	Case numbers (top to bottom)
55	66
60	
65	236
70	
75	
80	224, 112, 242, 176
85	24, 58, 146, 60
90	104, 134, 92
95	34
100	218, 120, 88, 292, 96, 78, 54, 72, 40, 110, 106, 304, 154, 86
105	52, 220, 190
110	250, 18, 206, 130
115	44, 212, 116, 30
120	136, 10, 50, 62, 8, 144, 84, 64
125	100, 80, 294, 32, 36
130	166, 150, 184, 108, 68, 74
135	164
140	234, 216, 82, 180, 168
145	244, 26, 230

FIGURE 67. Distribution of 67 boys by case numbers according to puberal gain in stem length: mean, 112.24 millimeters; standard deviation, 20.37 millimeters; median, 113.12 millimeters; Q_1, 101.62 millimeters; Q_3, 128.65 millimeters.

this close relationship. Case 36, by his unusual relative gain in stem length, changed his position from just below the mean at onset to above the mean at the end of the puberal period. However, he was back at his old position below the mean at Point d + 3 in the postpuberal period.

It is interesting to note that there were boys scattered all along the diagram who gained relatively more in leg length than in stem length. Outstanding cases were 242, 72, 86, 144, 74, 150, and 180. Except for Cases 242 and 150 these were all boys above the mean in height at the

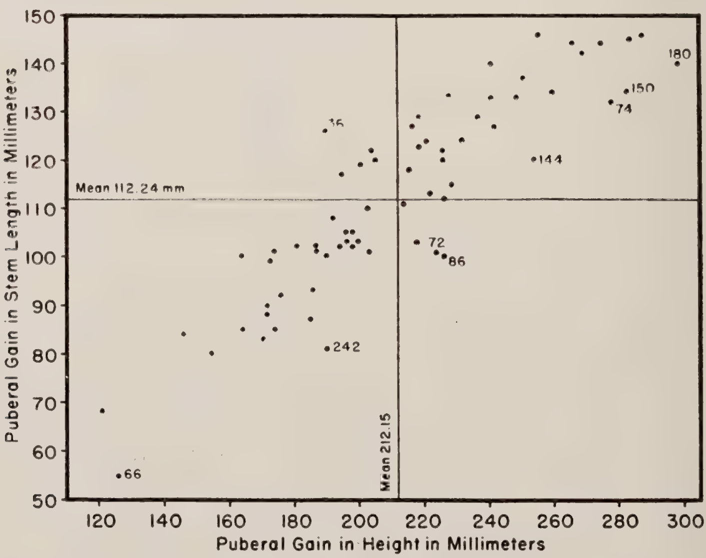


FIGURE 68. Relation of the gain in stem length and the gain in height during the puberal growth period for height for 67 boys. Coefficient of correlation .894, P.E. ± .016. The case numbers (except Case 36) indicate boys with relatively large gain in leg length.

puberal onset; all except Case 242 were above the mean in the post-puberal period.

Percentage gain in stem length. We analyzed the puberal gain in stem length in relation to the measurements in stem length at the onset of the puberal period. The percentage gain in stem length during the puberal period for the 67 boys is shown in Figure 69.

								130						
								304			10			
							110	88			80			
							292	220	206	64	100	108		
							106	218	44	84	68	166		
					58		96	78	30	136	294	234	180	
					146	24	86	52	18	32	36	62	216	
					242	104	54	120	40	116	50	184	82	
					224	134	34	72	250	144	212	168	244	230
	66		236	176	112	60	92	154	190	8	74	130	164	26
Per cent gain stem length from b to d	6	7	8	9	10	11	12	13	14	15	16	17	18	19

FIGURE 69. Distribution of 67 boys by case numbers according to percentage gain in stem length during the puberal growth period (b — d): mean, 14.54 per cent; standard deviation, .80 per cent; median, 14.53 per cent; Q_1, 12.92 per cent; Q_3, 16.62 per cent.

The range of percentage gain was from 6.70 per cent to 19.33 per cent. The distribution is very similar to that for actual gain in Figure 67. The coefficient of correlation between actual gain and percentage gain is .970, P.E. ±.005.

Relation of puberal gain in stem length to other factors. There seem to be several growth characteristics which have a relationship to the actual or percentage gain in stem length during the puberal growth period. In Table 24 a series of correlations is given. Boys made gains in stem length in relation to the length of the puberal period. The correlation of percentage gain with the puberal duration is .667. This is slightly less than the correlation of height gain and duration of the puberal period (.771).[3]

The correlation between age at puberal onset and puberal percentage gain in stem length during the puberal period was —.344, P.E. ±.073. This is shown in the scatter diagram in Figure 70. Again, this correlation was slightly less than the correlation of height gain and age at onset (—.483). The tendency for boys who were younger at the onset of the period to make a larger puberal percentage gain in stem length than the boys who were older was very slight. In Figure 70 Cases 36 and 130 stand out because they were among the oldest at onset and yet made puberal gains in stem length near the mean.

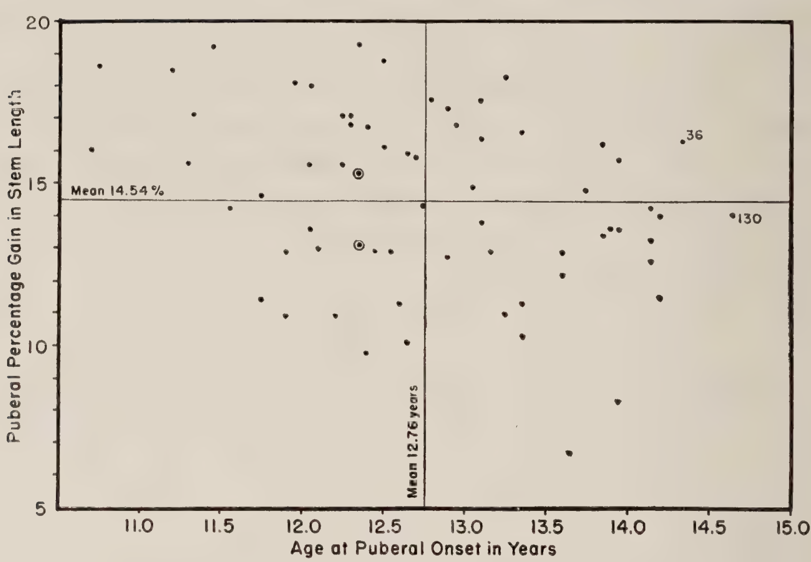


FIGURE 70. Relation of the percentage gain in stem length during the puberal growth period for height and age at the puberal onset. Coefficient of correlation —.344, P.E. ± .073. Cases 36 and 130 made unusually large gains for late developers.

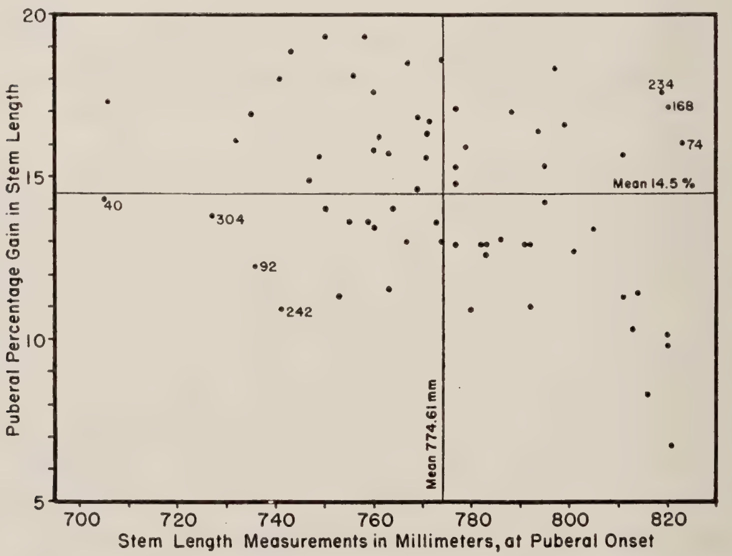


FIGURE 71. Relation of percentage gain in stem length during the puberal growth period for height and stem length measurements at the puberal onset. Coefficient of correlation —.367, P.E. ± .071 for 67 cases. The four extreme cases who had short trunks and made small gains are indicated on the diagram, as are the three cases who made large gains in spite of long trunks. If these seven cases are eliminated, the coefficient of correlation increases to —.604, P.E. ± .055.

The tendency for boys with shorter trunks at onset to make a higher percentage gain in stem length than boys with longer trunks was a little greater. The correlation between stem length measurements at onset and puberal percentage gain in stem length is —.367. If age is held constant, this increases to —.401. As can be seen in the scatter diagram in Figure 71, there are four cases whose stem length was below the mean at the onset who made relatively small puberal gains in stem length (Cases 40, 304, 92, and 242), and three cases whose stem length was above the mean who made relatively large gains in stem length (Cases 234, 168, and 74). If these seven cases are omitted, the correlation between stem length measurement at onset and puberal percentage gain increases to —.604, P.E. ±.055.

Table 24 CORRELATIONS OF PUBERAL GAIN IN STEM LENGTH WITH OTHER MEASURES

	Number of Cases	PUBERAL GAIN IN STEM LENGTH			
		Millimeter Gain		*Per Cent Gain*	
		r	P.E.	r	P.E.
Stem length measurements at onset	67 60*	−.187	±.079	−.367 −.604	±.071 ±.055
Stem length measurements at onset (age constant)	67			−.401	
Stem length/height ratio at onset	67 61†	.168 .390	±.080 ±.074	.121 .375	±.081 ±.074
Age at puberal onset	67			−.344	±.073
Puberal duration	67			.667	±.046

* Omitting seven cases most atypical in this relationship.
† Omitting six cases most atypical in this relationship.

On the other hand, the relation between stem length/height ratio and puberal gain in stem length is inclined to be quite variable. The boys who had a low ratio (i.e., stem length short in relation to total height) had a slight tendency to gain less in stem length than the boys who had a high ratio. The correlations are positive but very slight for the relation of both actual and percentage gain to stem length/height ratio at onset (r. .168 and r. .121, respectively). The scatter diagram in Figure 72 shows several cases with stem length/height ratios at onset above the mean who made relatively small gains, the extremes being Cases 66 and 176, and four cases with

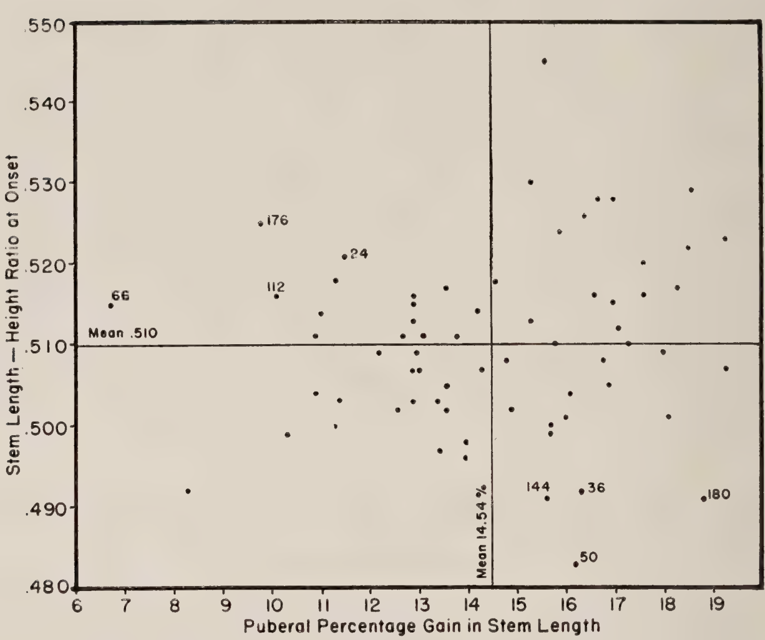


FIGURE 72. Relation of the percentage gain in stem length during the puberal period for height growth to the stem length/height ratio at the puberal onset. Coefficient of correlation for 67 cases .121, P.E. ± .081. Note Cases 66 and 176 who had high ratios and made small gains, and at the other extreme the four cases who had low ratios but made large gains. Omitting these six cases, the coefficient of correlation increases to .375, P.E. ± .074.

low ratios who made relatively large gains (Cases 36, 50, 144, and 180). However, even if these six cases are eliminated, the correlations of stem length/height ratio at onset with actual gain increases only to .390, and with percentage gain in stem length to .375.

COMPARISON OF PUBERAL GAIN IN STEM LENGTH WITH PREPUBERAL AND POSTPUBERAL GAINS

The mean stem length growth for the 67 boys during the prepuberal period (b — 3 to b) was 21.86 millimeters, or .86 inch; during the puberal period (b to d) 112.24 millimeters, or 4.41 inches; during the postpuberal period 87.72 millimeters, or 1.13 inches. The mean duration of the puberal period (2.81 years) was slightly greater than the sum of the mean duration of the prepuberal and postpuberal periods (2.50 years). The mean gain in stem length during the puberal period (112.24 millimeters, or 4.41 inches) exceeded the combined gains of the other two periods (50.58 millimeters, or 1.99 inches) in the ratio of approximately 11 to 5.

TIMING RELATIONS BETWEEN APEX GROWTH FOR HEIGHT AND FOR STEM LENGTH

In this section we will analyze the growth of stem length in relation to the puberal growth period for height in order to determine: (1) to what extent the most rapid period of growth in stem length occurred within the puberal growth period of height, and (2) whether the apex for stem length occurred preceding, simultaneously, or following the apex for height.[4]

In analyzing the relations between the time when boys had their most rapid growth in height and the time when they had their most rapid growth in stem length, we have compared the ages of the boy at the time of most rapid growth in each of these dimensions. The time when the most rapid growth takes place we have called the "apex." [5]

In all except one of our 67 cases, the growth velocity apex for stem length falls within the period of puberal growth in height, but in only one third of the cases do the apex for stem length and the apex for height occur in the same six month period.

				236						
				224						
				216						
				184						
				180						
				164						
				144						
				130						
				110						
				106						
				104	166					
				96	304					
				92	292					
				82	250					
			40	80	244	66				
			294	62	190	242				
			234	60	168	88				
			108	54	116	72	212			
			84	44	112	52	154	68		
			78	34	74	32	100	230		
			58	26	36	10	50	150		
			30	24	120	218	18	134		
	136		64	8	220	146	86	206		176
Difference in years	1.05–1.50	.55–1.00	.05–.50	0	.05–.50	.55–1.00	1.05–1.50	1.55–2.00	2.05–3.00	3.05
	Preceding height apex					Following height apex				

FIGURE 73. Distribution of 67 boys by case numbers according to time relation of stem length apex to height apex. 0 indicates simultaneous occurrence. Years to the left indicate apex stem length prior to height growth apex; years to the right, apex stem length after height growth apex.

Figure 73 shows the distribution of the 67 boys according to the time relation of the apex for stem length growth and the apex for height growth. The time relations are summarized in Table 25.

It will be noted that the apex for stem length is asynchronous with the apex for height in two thirds of the cases, and that this asynchrony ranges from 1.5 years before the height apex to 3.05 years after the height apex. On the other hand, in slightly more than two thirds of the cases the apex for stem length occurred either synchronously with the apex for height or six months before or six months after. There was a much greater tendency for the stem length apex to follow the height apex than to precede it. In 50.75 per cent of the cases the stem length apex followed, and in only 14.92 per cent of the cases did it precede the height apex.

Figures 74a, b, c, d, and e illustrate the variations in apex timing relation between stem length and height during the adolescent growth period.

CONFIGURATION OF THE GROWTH PROFILE FOR STEM LENGTH

By looking at the growth profiles for stem length which are presented in Figures 74a, b, c, d, and e, the reader can see the individual

Table 25 TIME RELATION OF APEX STEM LENGTH TO APEX HEIGHT

Relation	*Number of Cases*	*Per Cent of 67 Cases*	*Years Difference*	
			Average	Range
Apex stem length synchronous with apex height	23	34.33		
Apex stem length precedes apex height	10	14.92	.60	.45–1.5
Apex stem length follows apex height	34	50.75	1.00	.25–3.05
Apex stem length follows end puberal growth period height	1	1.49		3.05
Apex stem length follows apex height within puberal growth period height	33	49.25	.93	.25–1.95
Apex stem length within + or − .5 years from height apex*	45	67.16		
Apex stem length within puberal growth period height	66	98.51		

* Includes cases in which the two apexes were synchronous.

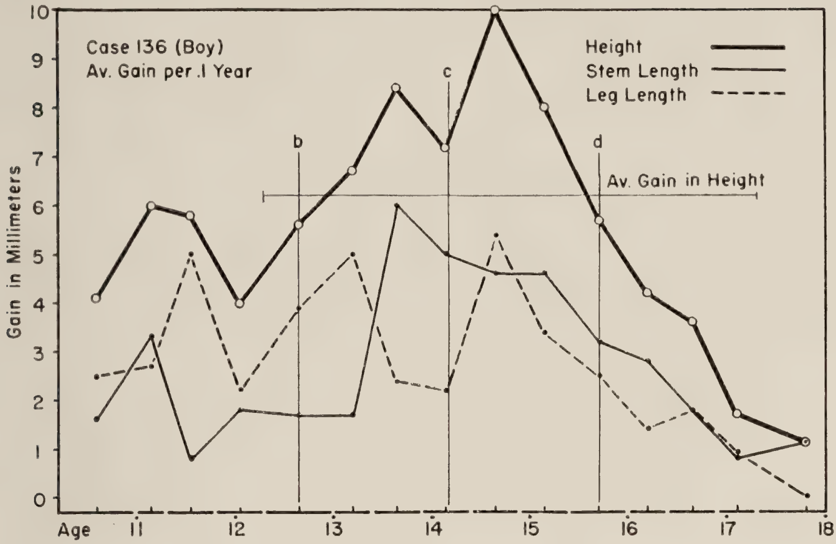


FIGURE 74a. Growth curve of boy (Case 136) illustrating time relation of stem length apex to height apex. Apex for stem length occurred 1.5 years prior to height apex. This was the only case of such marked priority for stem length apex.

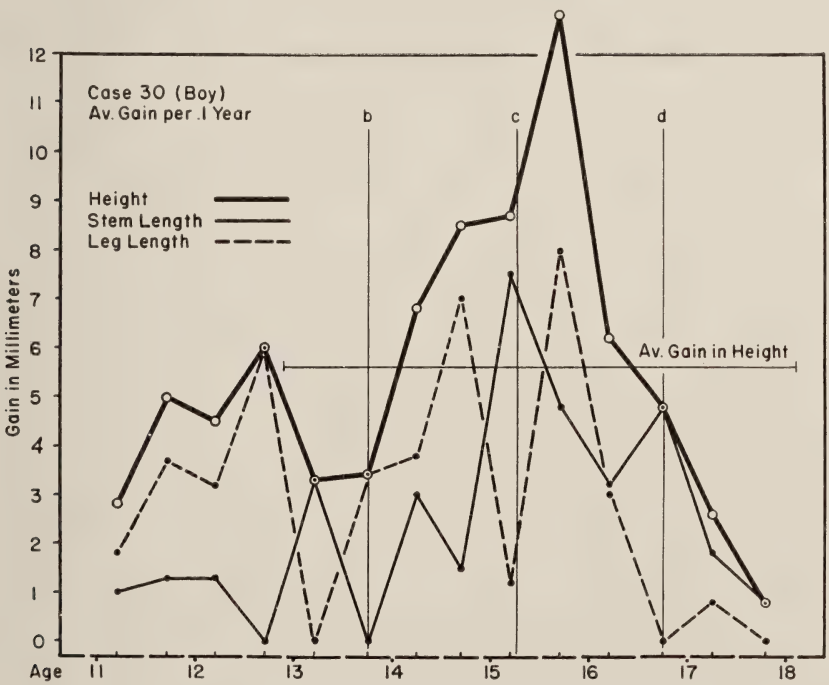


FIGURE 74b. Growth curve for boy (Case 30) illustrating time relation of stem length apex to height apex. Apex for stem length occurred .5 year prior to height apex. There were eight others, 11.94 per cent, with about the same priority for stem length apex.

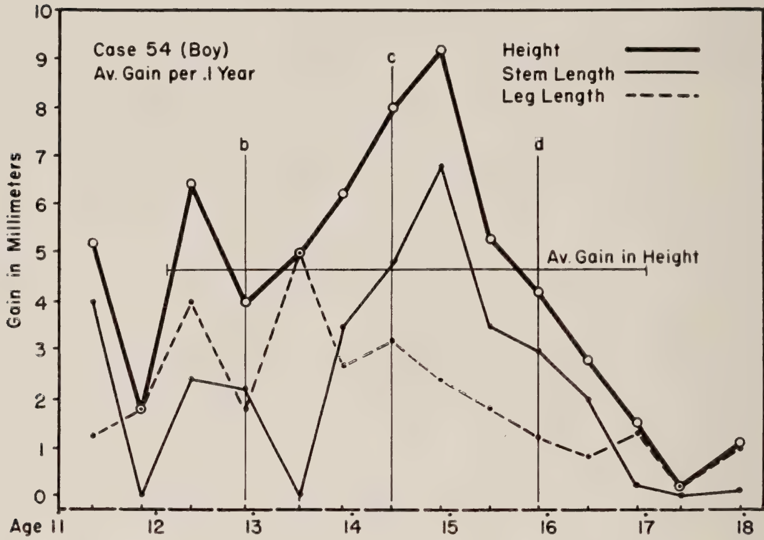


FIGURE 74c. Growth curve of boy (Case 54) illustrating simultaneous occurrence of apex for stem length growth and apex for height growth. There were 23 such cases (34.33 per cent).

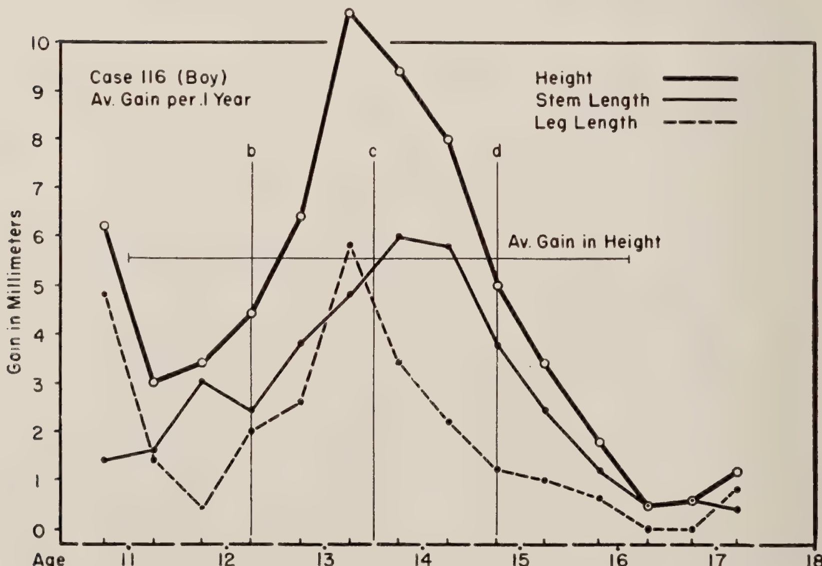


FIGURE 74d. Growth curve for boy (Case 116) illustrating time relation of stem length apex to height apex. Apex for stem length was .5 year after height apex. There were 13 cases (19.40 per cent) with apex for stem length between .25 year and .5 year after height apex.

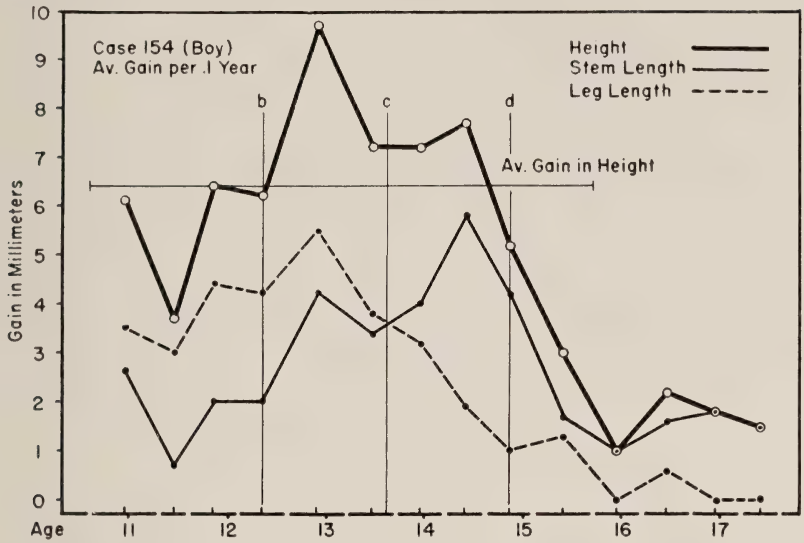


FIGURE 74e. Growth curve for boy (Case 154) illustrating time relation of stem length apex to height apex. Apex for stem length was 1.5 years after height apex. Nine cases (13.43 per cent) had a lag as long or longer than this for the apex of stem length. This curve illustrates, also, the fact that in 70 per cent of our sample the stem length apex occurred in the second half of the puberal growth period for height (c — d). Note the striking similarity of configuration between the profiles for leg length and stem length with marked difference of timing.

differences, the general pattern which seems to be characteristic of stem length growth, and the points of difference between height growth profiles and stem length growth profiles. The comparison of more than a hundred such profiles leads us to the following conclusions.

General characteristics of the stem length profile. The average distance from the zero base line is slightly more than half that of the height profile. The trend just preceding the onset (b) of the puberal period for height is upward, and the trend after the close (d) of the puberal period for height is downward. But in the early part of the prepuberal period the profile line for stem length usually dips more sharply than does that for height, while in the postpuberal period the stem length profile line closely parallels the height line. These stem length characteristics are well shown in Figures 75 and 76.

The steep upward trend, the apex inflection, and the succeeding rapid descent of the puberal phase for stem length are easily recognized in all but a few of the profiles.

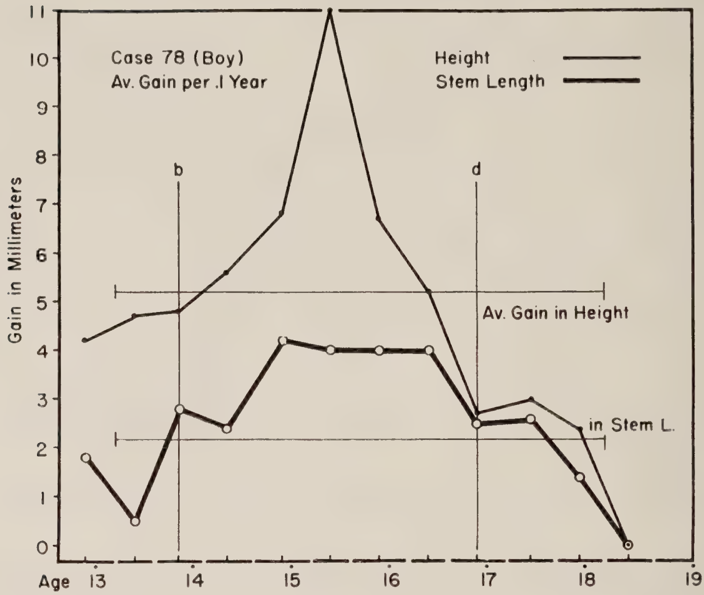


FIGURE 75. As in Case 78, shown above, the profile of stem length growth usually dips more sharply in the early part of the prepuberal period than does the height profile line. During the postpuberal period the two lines are usually very closely parallel.

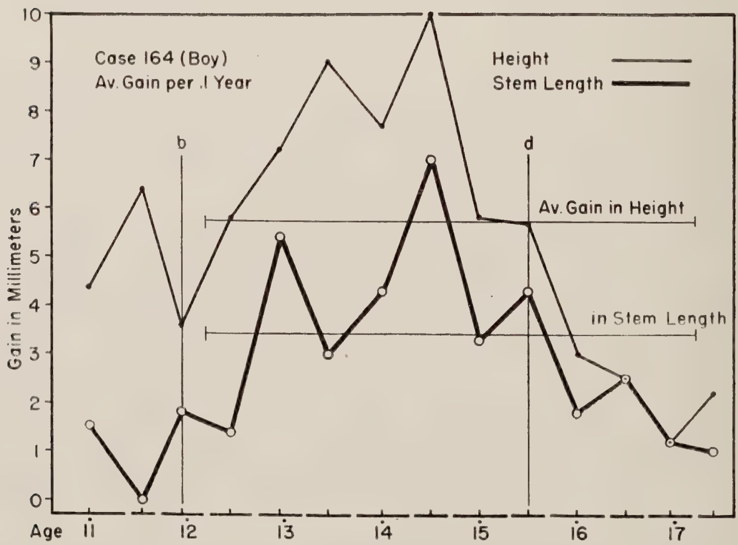


FIGURE 76. The stem length growth profile, shown above (Case 164), is one of nine in which a major dip to the zero base line occurred during the prepuberal period. In this case there were three major peaks above the five year average.

Incidence of major peaks and dips.[6] In the stem length profiles for our 67 boys there were 130 major peaks during the adolescent years which the data covered. This gives a mean number of 1.94 for the group. The range was from 1 to 4. In 21 of the profiles the puberal apex was the only major peak (see Case 78 in Figure 75); in 31 profiles there was one major peak in addition to the puberal apex; in 13 profiles there were two additional major peaks (see Case 164 in Figure 76); in two profiles there were three additional major peaks.

Of the 67 profiles there were 9 which showed the profile dipping once to the zero base line and then rising again to above the five year average. In every instance the major dip occurred during the prepuberal period. Such a profile is shown in Figure 76.[7]

CHANGES IN RATIO OF STEM LENGTH TO HEIGHT

We analyzed the data from the boys to determine what changes there might be during the process of growth in the relative length of stem and legs. This analysis was made through a study of the ratio of stem length to height at the four developmental points. The distribution of the 67 boys is shown in Figures 77a, b, c, and d. Table 26 presents the statistical analysis.

There were three boys who were consistently among the five lowest in each distribution (Cases 50, 180, and 144). Photographs of Case 180 will be found in Figures 49b and 105b on pages 89 and 183, and of Case 144 in Figure 95 on pages 168-69.

Among the upper five in each distribution there were four boys (Cases 44, 100, 116, and 216). Photographs of Case 44 will be found in Figure 58b, page 105; of Case 116 in Figures 37b and 40, pages 70 and 78; of Case 216 in Figure 33b, page 64.

The consistency of the position of individual boys in the group at the four distributions was high. The Pearson coefficient of correlation between the ratio of stem length to height at the prepuberal and the postpuberal measurements was .858, P.E. ±.022. Case 168, who made unusually large increases in ratio, and Cases 242 and 136, who made unusually small increases, were out of the general trend. There was a similar high correlation between the ratios at the onset and end of the puberal period. The Pearson coefficient of correlation was .876, P.E. ±.019. Cases 242 and 86 made unusually small increases, while Case 36 made an unusually large increase during the puberal period.

The curve of stem length/height ratio. The form of the growth curve for the ratio of stem length to height is probably more uniform for our 67 cases than any other growth curve which we analyzed. In general, it has the

following characteristics: deceleration during the prepuberal period to a dip or lowest point which occurs usually between the onset and middle of the puberal period; from then a rise to the end of the puberal period; in the postpuberal period either a continuing rise, a rise with a drop at the end, or a rhythm of slight accelerations and decelerations. The number of cases which follow the pattern described above are given in Table 27.

						292								
						242								
						220								
						120	304	112						
						54	86	96		82				
						224	10	184		250				
						206	230	146	224	218				
				74	34	88	168	80	8	58				
			236	34	72	212	40	66	234	26				
			144	190	32	104	164	154	68	110	294			
			180	84	106	52	92	108	66	60	176	216	136	
	50		36	78	130	30	62	18	64	24	150	100	44	116
Ratio of stem length to height	.488	.492	.496	.500	.504	.508	.512	.516	.520	.524	.528	.532	.536	.540

FIGURE 77a. Distribution of 67 boys by case numbers according to ratio of stem length to height during prepuberal period: mean, .515; standard deviation, .010; median, .514; Q_1, .508; Q_3, .523.

								304								
						106		146								
						104		120								
						52	292	54	168	60						
						206	230	64	96	18						
						88	72	62	66	244						
					224	34	40	154	250	218						
					84	164	220	108	58	166	26		44			
					130	74	10	92	86	112	82	294	216			
			180	236	78	134	242	80	8	110	24	176	150			
	50		144	36	190	32	212	30	184	68	234	136	100			116
Ratio of stem length to height	.480	.484	.488	.492	.496	.500	.504	.508	.512	.516	.520	.524	.528	.532	.536	.540	.544

FIGURE 77b. Distribution of 67 boys by case numbers according to ratio of stem length to height at onset of puberal period: mean, .510; standard deviation, .011; median, .510; Q_1, .502; Q_3, .517.

Ratio of stem length to height	Case numbers (top to bottom)
.484	180
.488	144
.492	242, 50, 36
.496	130, 236, 74
.500	134, 104, 86, 32, 72, 190
.504	224, 30, 88, 206, 78
.508	212, 154, 92, 58, 52, 40, 220, 146, 84, 230, 64, 80, 230
.512	106, 96, 66, 54, 18, 184, 166, 292, 250, 64, 10, 120, 112
.516	218, 108, 60, 24, 62, 82, 68
.520	82, 8, 304, 26, 234, 150, 110
.524	136, 244, 176, 168
.528	100
.532	294, 216
.536	44
.540	
.544	
.548	
.552	116

FIGURE 77c. Distribution of 67 boys by case numbers according to ratio of stem length to height at end of the puberal period: mean, .512; standard deviation, .011; median, .512; Q_1, .507; Q_3, .521.

Ratio of stem length to height	Case numbers (top to bottom)
.492	180
.496	236, 144, 50
.500	190, 242
.504	36, 86, 72, 74
.508	230, 220, 146, 104, 32, 52, 78, 206, 224, 134
.512	164, 18, 166, 34, 212, 84, 30
.516	292, 250, 108, 106, 58, 10, 92, 54, 40, 154, 120, 88, 64
.520	218, 62, 184, 112, 68, 234, 96
.524	136, 244, 110, 80, 150, 82, 24, 66, 26
.528	168, 8, 304, 60
.532	176
.536	100, 294
.540	44, 216
.544	
.548	
.552	
.554	116

FIGURE 77d. Distribution of 66 boys by case numbers according to ratio of stem length to height during the postpuberal period: mean, .517; standard deviation, .011; median, .517; Q_1, .510; Q_3, .525.

The lowest ratio of stem length to height occurred in 64 cases (95.52 per cent) during the puberal period; in the other 3 cases it occurred during the prepuberal period. Between the onset of the puberal period and the mid-point of the period, over three fourths of the cases had the dip in the curve (79.10 per cent). This dip was on the average .96 year after the onset of the puberal period and .36 year before the mid-point of the period. Table 28 summarizes these findings.

Table 26 RATIO OF STEM LENGTH TO HEIGHT—67 BOYS

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3
Prepuberal (b − 3)	.488–.541	.515	.010	.514	.508	.523
Onset of puberal (b)	.483–.545	.510	.011	.510	.502	.517
End of puberal (d)	.487–.552	.512	.011	.512	.507	.521
Postpuberal (d + 3)*	.495–.554	.517	.011	.517	.510	.525

* Sixty-six cases.

Table 27 CHANGES IN PROFILE OF STEM LENGTH/HEIGHT RATIO

	Number of Cases	*Per Cent of 67 Cases*
Deceleration to dip	62	92.54
Acceleration from dip to end of puberal period	63	94.03
Postpuberal:		*Per Cent of 66 Cases*
Continued acceleration	17	25.74
Continued acceleration with deceleration at final examination	15	22.73
Fluctuations of acceleration and deceleration	34	51.51

Table 28 TIMING OF THE LOWEST RATIO OF STEM LENGTH TO HEIGHT—67 BOYS

	Number of Cases	*Per Cent*
Preceding onset puberal period	3	4.48
During puberal period	64	95.52
Synchronous with onset	8	11.94
During first half puberal period	34*	50.75
Synchronous with mid-point puberal period	11†	16.42
During second half puberal period	11	16.42

* Four of these cases had a second low point in the second half of the puberal period; one had an additional low point in the prepuberal and one synchronous with the mid-point.

† One of these cases had a second low point in the postpuberal period.

Several curves of stem length/height ratio which illustrate these findings are shown in Figures 78, 79, and 80.

Relation of stem length/height ratio to puberal gain in stem length. There was a very slight tendency for boys who were short-waisted (in relation to height) to gain less and those who were long-waisted to gain more in stem length during the puberal period. In Figure 72 there are seven boys who do not conform to this general pattern. Four cases (Cases

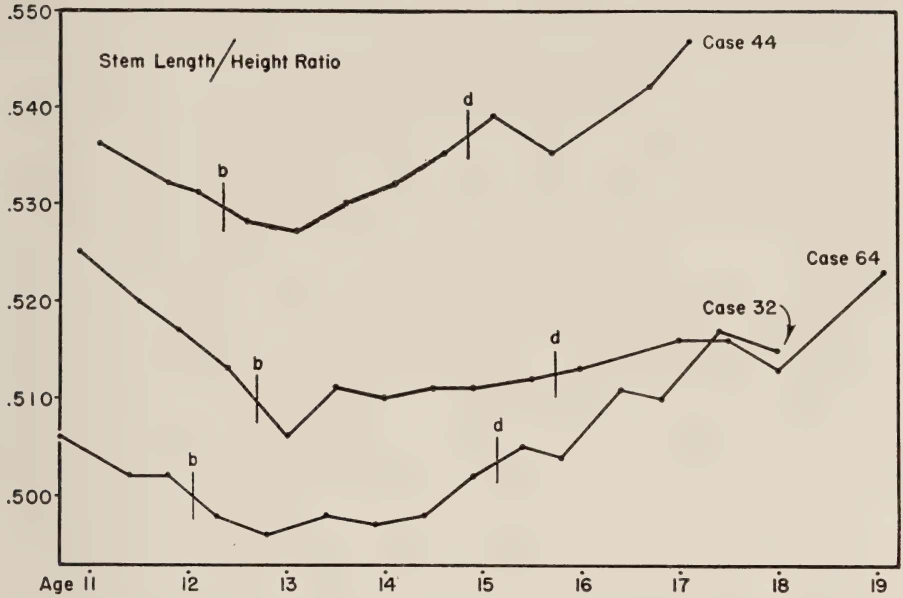


FIGURE 78. Examples of curves where the lowest point in stem length/height ratio occurred during the first half of the puberal period. Case 44 was consistently high and Case 32 consistently low in stem length/height ratio. (See photographs of Case 44 in Figure 58b, page 105, and of Case 32 in Figure 35b on page 67.)

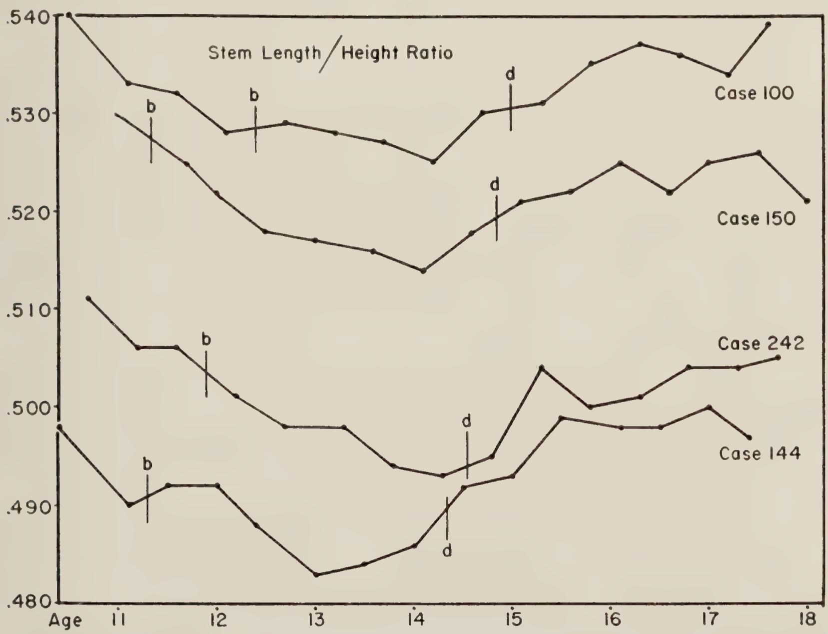


FIGURE 79. Examples of curves where the lowest point in stem length/height ratio occurred during the second half of the puberal period. Case 100 was consistently high and Case 144 consistently low in stem length/height ratio. (See photographs of Case 100 in Figure 20, page 41, and of Case 144 in Figure 95, page 169.)

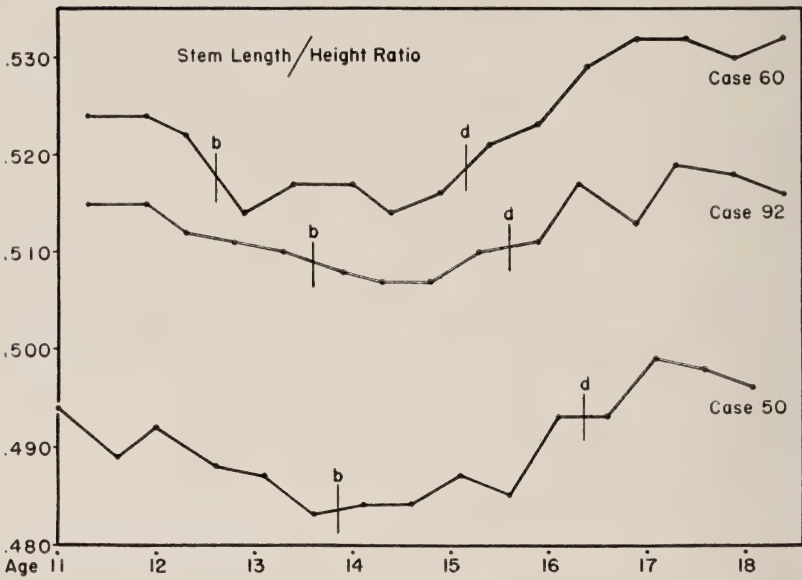


FIGURE 80. The curves in this chart are all exceptions to the rule. Case 60 is an example of the four cases who had two dips in stem length/height ratio during the puberal period. The curve for Case 92 illustrates the eleven cases with the dip exactly at the mid-point of the puberal period. The curve for Case 50 illustrates the three cases with the dip preceding onset of the puberal period.

24, 66, 112, and 176) had relatively high S L/H ratios but made small gains in stem length. In spite of the small gain in stem length each maintained a relatively high S L/H ratio until maturity. Four cases (Cases 36, 50, 144, and 180) had low S L/H ratios but made large gains in stem length. Each of these four cases maintained his position of extremely low stem length/height ratio to the final examination despite the large puberal gains in stem length.

The Pearson coefficient of correlation for the 67 boys between stem length/height ratio at onset and puberal gain in stem length was .168, ±.080. If the seven cases discussed above are eliminated, the correlation is increased to .390, ±.074.[8]

Section B GROWTH IN LEG LENGTH

From about six months after birth until the child reaches the apex of his puberal growth in height, the average rate of increase for leg length is greater than that for stem length. This relation is shown in Figure 2 on page 7. During childhood the legs become gradually relatively longer,

and the acceleration of leg length growth is one of the earliest signs that the boy is entering the puberal cycle.

Length of legs is, of itself, less important than length of trunk from the point of view of organic fitness, but the ratio between stem length and leg length may be significant for health, and wide variation from the group in this respect may constitute a real handicap in achieving wholesome social adaptation.

For the student of somatic development during adolescence, the study of leg length growth yields valuable information as to individual differences and for understanding the sequence of growth phenomena. In this section we will present and discuss our findings concerning leg length in relation to developmental points for height and also make an analysis of the configuration of the leg length growth profiles.

Millimeters	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790	800
										68										
										58										
										8										
										96										
							166			164		112	106							
							110			206		78	130							
							108			18		234	292							
						218	10	230	80	176		86	180		36					
					136	82	304	242	88	146	190	30	84		100	224	50			
				62	60	24	294	212	150	184	250	220	72	168	52	134	104			74
	116			40	44	216	92	26	64	154	244	120	66	54	34	144	32			236

FIGURE 81a. Distribution of 67 boys by case numbers according to leg length measurements during the prepuberal period (b — 3): mean, 708. 82 millimeters; standard deviation, 39.70 millimeters; median, 712.16 millimeters; Q_1, 679.56 millimeters; Q_3, 736.08 millimeters.

mm	620	630	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790	800	810	820	830	840
														78									
													244	234		106							
													58	220		66							
									136				146	8		168							
								304	218			86	96	250		30							
								294	150	108	166	206	80	72		130				224			
							40	26	82	18	212	64	184	164	54	112		144		50			
							216	44	24	110	88	242	176	68	84	292		36		32			
	116						62	100	60	92	10	230	154	120	190	180	34	52	104	134	74		236

FIGURE 81b. Distribution of 67 boys by case numbers according to leg length measurements at the onset of the puberal growth period for height (b): mean, 744.98 millimeters; standard deviation, 40.69 millimeters; median, 746.46 millimeters; Q_1, 715.50 millimeters; Q_3, 769.54 millimeters.

700	710	720	730	740	750	760	770	780	790	800	810	820	830	840	850	860	870	880	890	900	910	920	930	940	950	960
															184											
													64	292	112											
													8	120	244	230										
													88	106	190	30										
													146	220	150	164										
											10		80	66	34	130										
											176		26	58	166	86	52									
							60	24	218		136		154	96	78	250	224		236							
							44	294	100		110		82	242	54	68	72		104			180				
116						304	40	62	92	216	108	212	18	206	84	36	168	234	134		50	32	144			74

FIGURE 81c. Distribution of 67 boys by case numbers according to leg length measurements at the end of the puberal growth period for height (d): mean, 844.04 millimeters; standard deviation, 43.36 millimeters; median, 846.84 millimeters; Q_1, 819.16 millimeters; Q_3, 867.09 millimeter.

710	720	730	740	750	760	770	780	790	800	810	820	830	840	850	860	870	880	890	900	910	920	930	940	950	960	970
															250											
														166	292											
														106	244											
														96	190											
												154		78	242											
												136		64	54	230										
												8	18	206	184	168										
												110	26	82	120	164	224		236							
							62		216			108	58	220	34	68	72		104							
							60	218	24	212		10	66	146	84	130	36	52	234		180					
116					304		40	294	44	92	100	176	80	88	150	30	112	86	134		50	32	144			74

FIGURE 81d. Distribution of 67 boys by case numbers according to leg length measurements during the postpuberal period for height (d + 3): mean, 854.82 millimeters; standard deviation, 43.22 millimeters; median, 858.00 millimeters; Q_1, 831.88 millimeters; Q_3, 877.95 millimeters.

LEG LENGTH MEASUREMENTS AT DEVELOPMENTAL POINTS

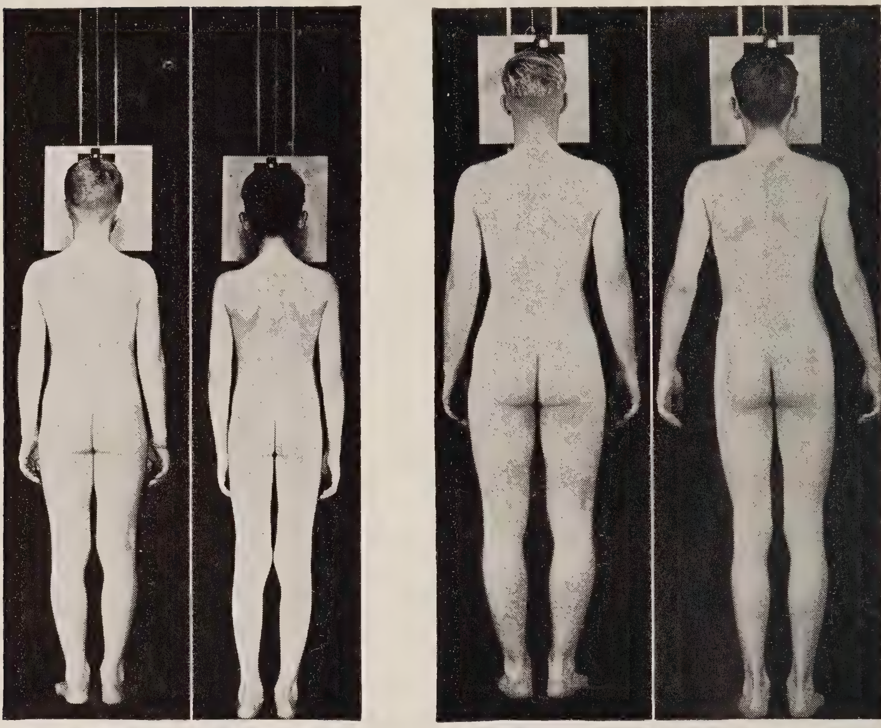
The leg length measurements for our sample were derived by subtracting the stem length from the height.[9] Distributions of the 67 boys according to leg length measurements at the four developmental points are shown in Figures 81a, b, c, d. The group data are summarized in Table 29.

It will be seen that at the third examination before the onset of the puberal growth period for height (Point b − 3) the boy with the longest legs measured 802 millimeters (31.58 inches) and exceeded by 190 millimeters (7.48 inches) the boy with the shortest legs. The distribution shows, however, that the three extreme boys were widely separated from the remaining 64 cases (Figure 81a). The mean of leg length for the group was 708.82 millimeters with a standard deviation of 39.70 millimeters.

At the onset of the puberal period (Point b) the mean had increased to 744.98 millimeters (29.33 inches) with a standard deviation of 40.69 millimeters (1.60 inches). The shortest legs measured 626 millimeters

Table 29 LEG LENGTH MEASUREMENTS DURING ADOLESCENCE—67 BOYS

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3	*Coefficient of Variation*
A. In Millimeters							
Prepuberal (b − 3)	612–802	708.82	39.70	712.16	679.56	736.08	5.60
Onset of puberal growth period (b)	626–843	744.98	40.69	746.46	715.50	769.54	5.46
End of puberal growth period (d)	704–967	844.04	43.36	846.84	819.16	867.09	5.14
Postpuberal (d + 3)	718–970	854.82	43.22	858.00	831.88	877.95	5.06
Puberal gain (b–d)	53–159	99.49	21.33	96.77	85.22	112.08	
B. In Inches							
Prepuberal (b − 3)	24.10–31.78	27.90	1.56	28.04	26.75	28.98	
Onset of puberal growth period (b)	24.65–33.19	29.33	1.60	29.39	28.17	30.29	
End of puberal growth period (d)	27.72–38.08	33.32	1.70	33.34	32.25	34.14	
Postpuberal (d + 3)	28.26–38.19	33.65	1.70	33.77	32.75	34.57	
Puberal gain (b–d)	2.09–6.26	3.92	.84	3.81	3.35	4.41	



Case 294 12.3 **Case 170** 11.6

Prepuberal period

Case 294 17.9 **Case 170** 17.2

Postpuberal period

FIGURE 82. Two relatively short boys with consistently similar stem length and consistently dissimilar leg length. Note that photographs are matched at gluteal fold. Growth curves for Case 294 will be found in Figure 64c, page 113.

(24.65 inches) and the longest 843 millimeters (33.19 inches), a difference of 217 millimeters (8.15 inches). The increase in growth had widened the total range, but the middle 50 per cent of the cases was slightly closer to the mean. (See interquartile range, Table 30.)

This tendency for the total range to increase while the mdidle 50 per cent became closer to the mean continued to the end of the puberal period (Point d). At that point the range was from 704 millimeters (27.72 inches) to 967 millimeters (38.08 inches), a difference of 263 millimeters (10.36 inches). The mean leg length at this time was 844.04 millimeters (33.23 inches) with a standard deviation of 43.36 millimeters (1.70 inches).

At Point d + 3 during the postpuberal period the shortest leg length measurement was 718 millimeters (28.26 inches) and the longest was 970 millimeters (38.19 inches), a difference of 252 millimeters (9.92 inches).

The mean for the group was 854.82 millimeters (33.65 inches) with a standard deviation of 21.33 millimeters (.84 inch).

Case 116 was consistently and by a wide margin the shortest legged boy in the group at each of the four points. The position of longest legged boy was shared by two boys. Case 236, a late developer, was the longest legged at the prepuberal point and at the onset of the puberal growth period. This was due to his long and extended prepuberal growth period.[10] Case 74, an early developer, had the greatest measurement for legs at the end of the puberal period (Point d) and at the postpuberal point (d + 3), while Case 236 moved toward the mean for the group.

The photographs shown in Figure 40, page 79, as illustrating consistent tallness and shortness in height during adolescence, also illustrate the extremes of difference in leg length. Figure 82 shows photographs of two boys, both rather short, whose stem length measurements were similar, but whose leg length measurements were quite different.

Table 30 VARIABILITY IN LEG LENGTH MEASUREMENTS

Time of Measurement	*Total Range*		*Interquartile Range*	
	Millimeters	Inches	Millimeters	Inches
Prepuberal (b − 3)	190	7.48	56.52	2.23
Onset puberal period (b)	217	8.15	54.04	2.13
End puberal period (d)	263	10.36	47.93	1.89
Postpuberal (d + 3)	252	9.92	46.07	1.81

Table 31 COMPARATIVE VARIATION IN LEG LENGTH

Time of Measurement	*Coefficient of Variation*		
	Leg Length	Stem Length	Height
Prepuberal (b − 3)	5.60	3.67	4.30
Onset puberal period (b)	5.46	3.67	4.02
End puberal period (d)	5.14	3.63	3.83
Postpuberal (d + 3)	5.06	3.58	3.65

Table 30 presents an interesting phenomenon of growth in leg length. Although the difference between the shortest and longest legs increased with growth, the middle fifty per cent gradually came closer to the mean. At onset the total range was 217 millimeters (8.15 inches), the interquartile range was 54.04 millimeters (2.13 inches). By the end of the puberal period the total range had increased to 263 millimeters (10.36

inches), but the middle fifty per cent of the cases were within 47.93 millimeters (1.89 inches) of each other. The coefficients of variation (Table 31) for leg length decreased consistently at each developmental point, which is further evidence that although the range was increasing the general variation among the group was becoming less with age.

As can be readily seen in the distributions, leg length varied among the 67 boys more than height and considerably more than stem length. This is substantiated by the coefficients of variation in Table 31.

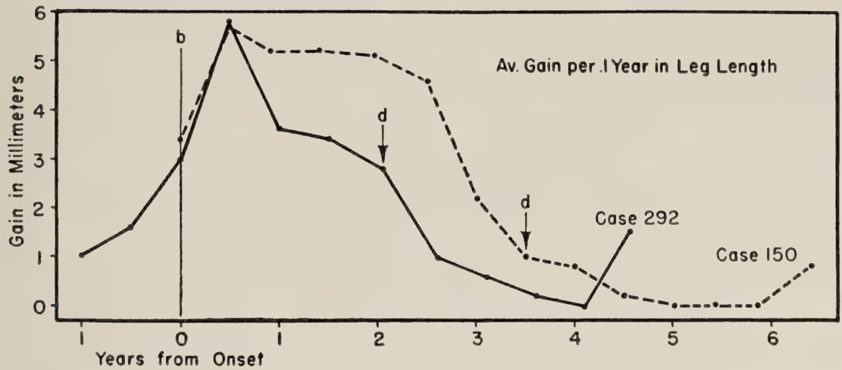
PUBERAL GAIN IN LEG LENGTH

The distribution of the 67 boys according to puberal gain in leg length is shown in Figure 83. The amount gained in leg length during the puberal period varied from 53 millimeters (2.09 inches) to 159 millimeters (6.26 inches). Actually, the two boys at the extremes in gain both were relatively long-legged (Cases 236 and 180). The amount of their gains was related to differences in the duration of the puberal period. The mean gain was 99.49 millimeters (3.92 inches) with a standard deviation of 21.33 millimeters (.84 inch). Fifty per cent of the cases gained between 85.22 millimeters and 112.08 millimeters (3.35 inches and 4.41 inches). Two boys, one of whom gained a relatively small amount in leg length during the puberal period (Case 292) and one who made a relatively large gain (Case 150), are contrasted in Figures 84a and b.

mm	Case numbers
50	236
55	
60	36, 304, 224
65	
70	106, 34, 66
75	292, 60, 116, 176
80	134, 52, 24, 92, 44, 8
85	146, 112, 40, 84, 54
90	218, 190, 130, 220, 104, 78, 294, 154, 80
95	212, 58, 120, 10, 96, 50, 108, 30
100	62, 206, 110, 168
105	250, 242, 136, 100, 68, 64
110	164, 244
115	184, 88, 32, 18
120	72, 216
125	82, 166, 86
130	144, 234
135	230
140	26
145	150, 74
150	
155	180

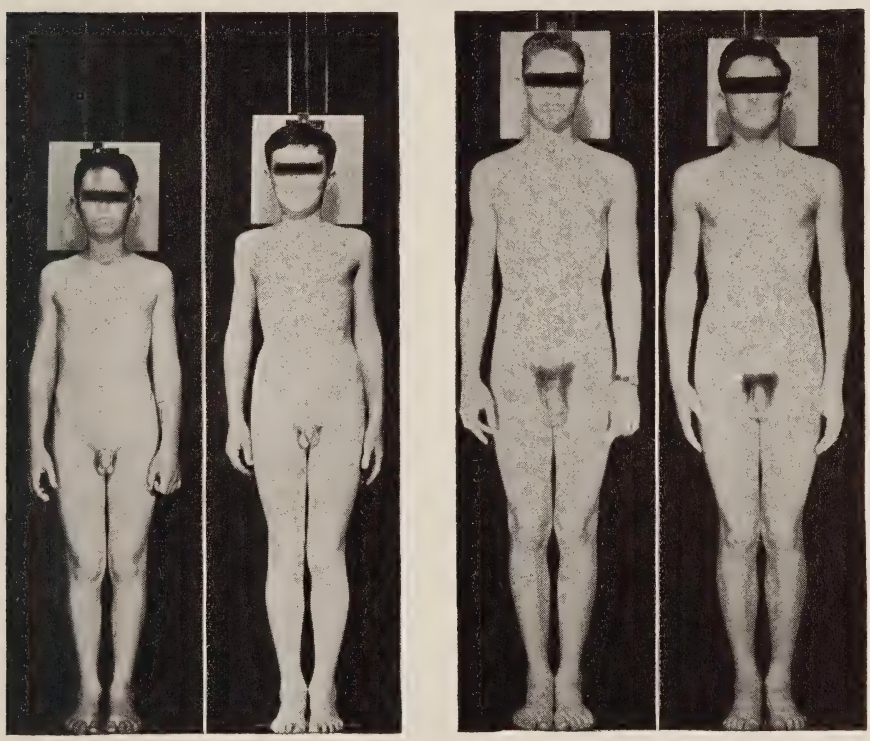
FIGURE 83. Distribution of 67 boys by case numbers according to puberal gain in leg length: mean, 99.49 millimeters; standard deviation, 21.33 millimeters; median, 96.77 millimeters; Q_1, 85.22 millimeters; Q_3, 112.08 millimeters.

Relation of actual puberal gain to percentage gain in leg length. The distribution of the 67 boys according to percentage gain in leg length is given in Figure 85. There was a high correlation between percentage gain and absolute gain in leg length (r. .962; P.E. ±.006).



a

FIGURE 84a. Growth curves of the two boys described in Figure 84b.



b

Case 150	Case 292	Case 150	Case 292
11.35	13.15	14.85	15.20

Puberal onset — Puberal end

FIGURE 84b. These boys represent contrasting growth in leg length during the puberal period. Case 292 had longer legs at onset by 65 millimeters. However, his puberal growth was short (2.05 years) and marked by only one six month spurt in leg length. Case 150 had a long puberal period (3.50 years) with a high level growth in leg length for two years. His puberal gain was 149 millimeters as against 79 millimeters for Case 292 (5.87 inches as against 3.11 inches). At the end of the puberal period the leg length of Case 150 was 5 millimeters greater than the leg length of Case 292. (See growth curves in Figure 84a.)

							220									
							190									
							154									
							146									
							130									
							116		250							
							104	294	242							
							92	218	212							
						112	80	120	206		184					
						84	78	108	168		100					
				304		60	50	96	110		88					
				106	292	54	44	58	68	244	72	166		234		
			224	66	176	52	30	40	64	164	62	144	82	230		180
	236		36	34	134	8	24	10	32	136	18	86	74	216	26	150
Per cent gain	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

FIGURE 85. Distribution of 67 boys by percentage gain in leg length during the puberal growth period (b—d): mean, 13.50 per cent; standard deviation, 3.07 per cent; median, 12.96 per cent; Q_1, 11.47 per cent; Q_3, 15.37 per cent.

Relation of puberal gain in leg length to puberal gain in height. As with stem length, there is a high correlation between gain in leg length and height during the puberal period. The Pearson coefficient of correlation is .907, P.E. ±.014. Case 66 gained somewhat more in leg length than might have been expected but even so was above the mean in stem length/height ratio at every developmental point. Case 36 gained somewhat less in leg length than might have been expected from his growth in height but was among the ten lowest in S L/H ratio at all four developmental points. In spite of the high correlation between puberal gains in height and leg length, there were boys who made almost identical gains in height but different gains in leg length. Figures 86a and b show the curves and photographs of Cases 110 and 8 as examples of this discrepancy.

Relation of puberal gain in leg length to puberal gain in stem length. The scatter diagram in Figure 87 shows the relation of gain in leg length to gain in stem length during the puberal growth period. The Pearson coefficient of correlation is .641 ±.049. Although there is a correlation between growth in these two measures, it is not so high as the correlation of either one with height.

A comparison of the percentage gains made in leg length with those made in stem length during the puberal period is given in Table 32. No boy made as large percentage gains in stem length as the three who were

highest in percentage gains in leg length. However, the boys made on the average one per cent greater increase in stem length during the puberal period than they made in leg length.

Table 32 COMPARISON OF PUBERAL PERCENTAGE GAINS IN LEG LENGTH AND STEM LENGTH

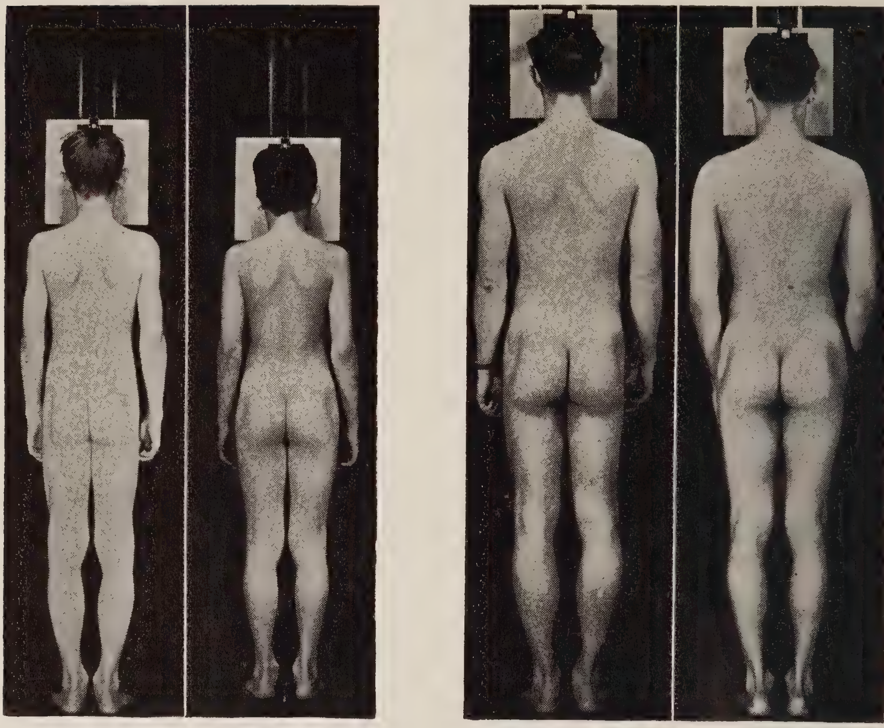
	Leg Length	*Stem Length*
Mean	13.50	14.54
Standard deviation	3.07	2.75
Median	12.96	14.53
Q_1	11.47	12.92
Q_3	15.37	16.62
Range	6–21	6–19
Interquartile range	3.90	3.70

Relation of puberal gain in leg length to age at puberal onset, and to puberal duration. In Table 33 a series of correlations is given showing the relation of gain in leg length during the puberal period to other growth characteristics. The younger boys tended to gain more in leg length than the older boys (r. —.621, P.E. ±.038). Gains were greater when the duration of the puberal period was longer (r. .733, P.E. ±.038). This corresponds to the relations of these factors with gains in both height and stem length.[11]

Table 33 CORRELATIONS OF PUBERAL GAIN IN LEG LENGTH WITH OTHER MEASURES

	Number of Cases	PUBERAL GAIN LEG LENGTH			
		Actual Gain		*Per Cent Gain*	
		r	P.E.	r	P.E.±
Leg length measurements at onset	67	−.134	.081	−.345	.073
Leg length measurements at onset (age constant)	67			−.237	.078
Stem length/height ratio at onset	67	.089	.082	.260	.077
	61*	.464	.068		
	59*			.597	.056
Age at puberal onset	67			−.621	.051
Puberal duration	67			.733	.038

* Omitting cases most atypical in this relationship



	Case 8	Case 110	Case 8	Case 110
C.A.	12.3	12.4	15.3	14.5

Onset puberal period — End puberal period

(Matched at gluteal fold.)

FIGURE 86a.

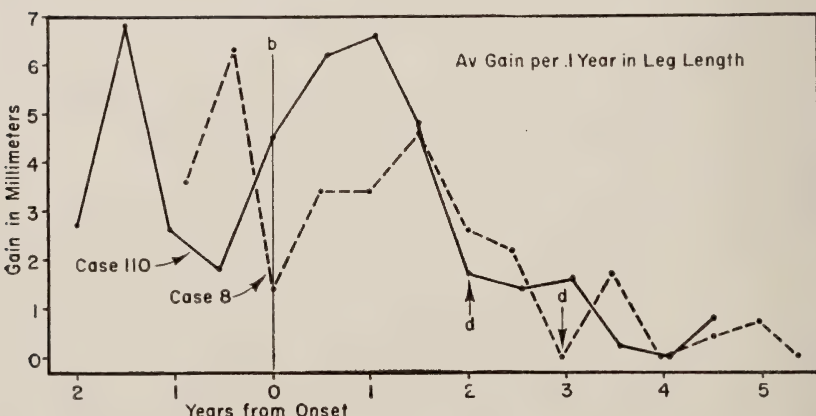


FIGURE 86b. Growth curves of gain in leg length of the two boys shown in Figure 86a.

Case 8 **Case 110**

17.9 17.2

Late adolescence

FIGURE 86c. These two boys made the same puberal gain in height. For Case 110 this gain was evenly divided between leg length and stem length. Case 8, on the other hand, gained only 82 millimeters in leg length and 122 millimeters in stem length. At the onset of the puberal period Case 110 had a higher stem length/height ratio than Case 8, but by the end of the period Case 8 was definitely a boy with relatively shorter legs and longer trunk than Case 110. (See growth curves in Figure 86b.)

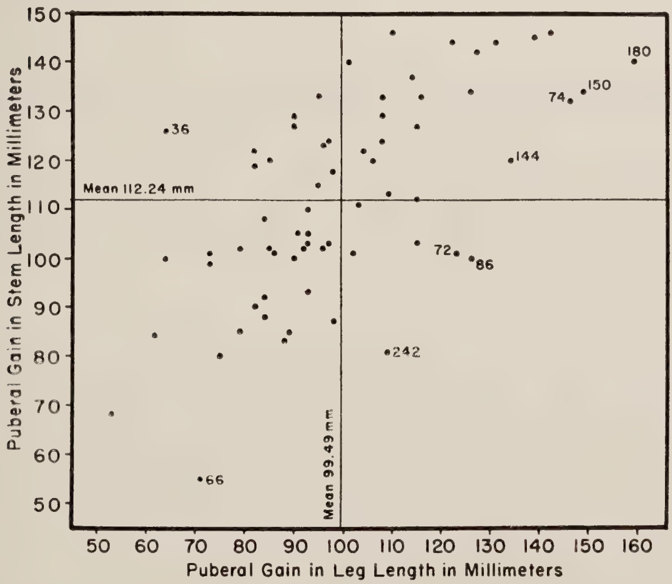


FIGURE 87. Relation of gains in leg length and stem length during the puberal growth period for height. Coefficient of correlation .641, P.E. ± .049. The cases marked on the diagram had either unusual growth in leg length or in stem length (Case 36). Compare Figure 68, page 124.

Relation of puberal gain in leg length to leg length measurement at puberal onset. The coefficient of correlation of leg length measurement at the puberal onset with actual gains in leg length is —.134, with percentage gain —.345. Figure 88 shows the wide variety of relationships. More short-legged boys make gains above the mean than below, and more long-legged boys make gains below the mean than above. There were three boys (Cases 74, 144, and 180) who, in spite of having long legs at onset, made large percentage gains in leg length. Case 74 was the youngest at onset and had a long duration. Case 144 was also young at onset and had a duration just below the third quartile. Case 180, although at the mean in age at

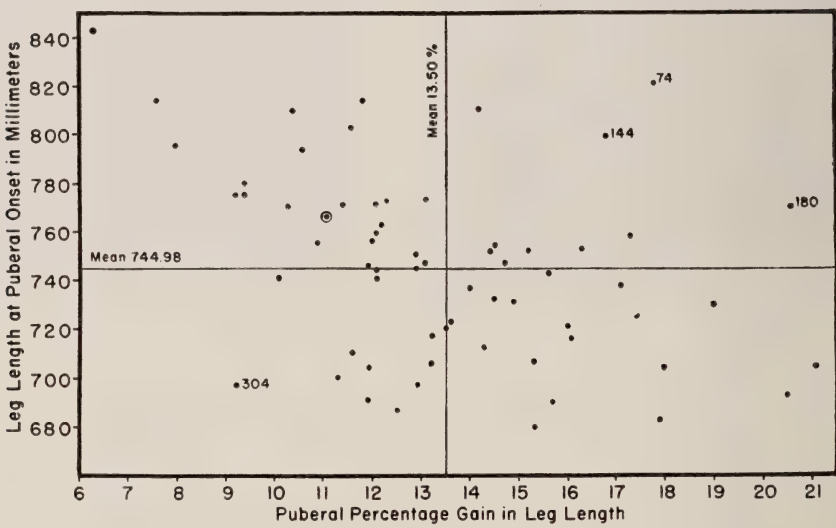


FIGURE 88. Relation of leg length measurement at the puberal onset and percentage gain in leg length. Coefficient of correlation —.345, P.E. ± .073. Case 304, with relatively short legs at onset, made small gains during a very short puberal period. Cases 74, 144, and 180 made large gains, though they had long legs at onset. Each had a relatively long puberal period.

onset, had the longest duration of any boy in the study. There was one boy (Case 304) who, in spite of very short legs at onset, made very small percentage gains in leg length during the puberal period. Case 304 was above the mean in onset age and had a very short duration. The correlation between puberal percentage gain in leg length and leg length measurement at onset is lowered to —.237 if age is held constant.

Relation of puberal gain in leg length to stem length/height ratio at puberal onset. The statistical relation of gain in leg length to the stem length/height ratio at onset was even less (coefficient of correlation .089,

P.E. ±.082). However, there are six cases in Figure 89 who followed extreme patterns. It will be seen in Figure 89 that three boys (Cases 44, 116, and 176) were short-legged (high S L/H ratio) at the puberal onset and gained less than average in leg length during the puberal period. These boys were in the upper quartile of stem length/height ratio throughout. They were short-legged, long-waisted boys and kept these proportions to maturity.

At the other extreme we find three boys who were long-legged at puberal onset (low S L/H ratio), made relatively large puberal gains in leg length, and continued to be short-waisted, long-legged boys (Cases 74, 144, and

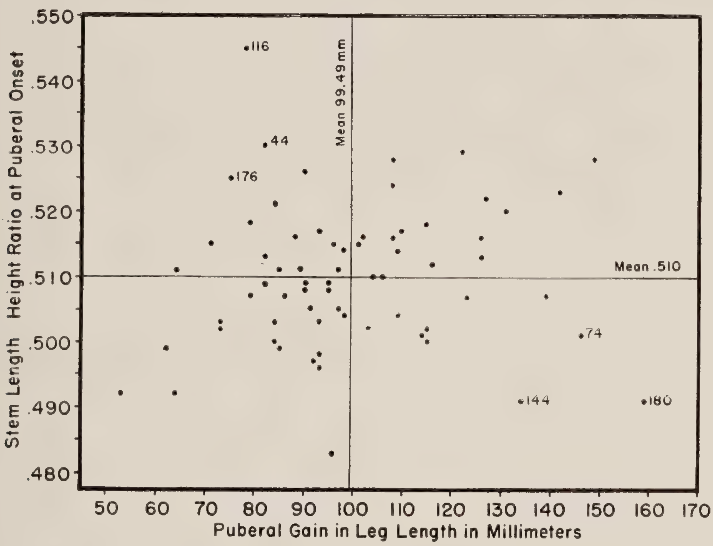


FIGURE 89. Relation of gain in leg length during the puberal growth period for height and stem length/height ratio at puberal onset. Coefficient of correlation for 67 boys is .089, P.E. ± .082. If the six extreme cases indicated on the diagram are eliminated, the correlation increases to .464, P.E. ± .068.

180). Cases 144 and 180 also made relatively large gains in stem length. Each had a long duration during the puberal period; Case 144 had a rate of growth above the mean and Case 180 just below the mean. These two boys were at every developmental point among the longest-legged (low S L/H ratio). If the six boys discussed above are eliminated, the coefficient of correlation between stem length/height ratio at onset and puberal gain in leg length increases to .464 ±.068.

If the percentage gain in leg length is used instead of the actual gain, these correlations are raised slightly. (See Table 33.) This reinforces the indication that, in spite of great variations, the boys who were long-legged

in proportion to total height had a slight tendency to gain less in leg length than the boys who were long-waisted. The same three boys made relatively small percentage gains (Cases 44, 116, and 176). Five long-legged boys made unexpectedly large percentage gains in leg length. These include Cases 74, 144, and 180, who made large actual gains, and in addition Cases 50 and 230. If these eight boys are eliminated the correlation increases from .260 to .597 with P.E. ±.056.

COMPARISON OF PUBERAL GAIN IN LEG LENGTH WITH PREPUBERAL AND POSTPUBERAL GAINS

The mean leg length growth for the 67 boys during the prepuberal period (b — 3 to b) was 36.16 millimeters, or 1.42 inches; during the puberal period (b to d) 99.49 millimeters, or 3.92 inches; during the postpuberal period 10.78 millimeters, or .46 inch. The mean gain during the puberal period (99.49 millimeters, or 3.92 inches) exceeded the sum of mean gains for the other two periods (46.94 millimeters, or 1.88 inches) in the ratio of approximately 11 to 5.

TIMING RELATIONS BETWEEN APEX GROWTH OF LEG LENGTH AND OF HEIGHT

The growth velocity apex for leg length fell within the puberal growth period for height in 86.57 per cent of the 67 boys. The remaining 9 cases

Table 34 TIME RELATION APEX LEG LENGTH TO APEX HEIGHT

Relation	*Number of Cases*	*Per Cent of 67 Cases*	*Years Difference*	
			Average	Range
Apex leg length synchronous with apex height	38	56.72		
Apex leg length precedes apex height	23	34.33	1.51	25–3.50
Apex leg length precedes onset puberal growth period height	9	13.43	2.72	1.90–3.50
Apex leg length precedes apex height within puberal growth period height	14	20.89	.73	25–1.45
Apex leg length follows apex height	6	8.95	.53	25–1.00
Apex leg length within + or −.5 year from height apex*	49	73.13		
Apex leg length within puberal growth period height	58	86.57		

* Includes synchronous.

(13.4 per cent) had their apex in leg length growth prior to the onset of the puberal growth period for height. Figure 90 shows the distribution of the 67 cases according to the time relation of the apexes of these two velocities.[12] Table 34 gives a summary of this distribution.

Difference in years		Case numbers
3.05–3.50	Preceding height growth apex	236, 206, 220
2.55–3.00	Preceding height growth apex	110, 164
2.05–2.50	Preceding height growth apex	68, 224
1.55–2.00	Preceding height growth apex	168, 8
1.05–1.50	Preceding height growth apex	54, 26
.55–1.00	Preceding height growth apex	294, 40, 250, 150, 216, 82
.05–.50	Preceding height growth apex	184, 180, 80, 62, 10, 44
0		304, 292, 244, 242, 234, 230, 218, 190, 176, 154, 146, 144, 136, 134, 120, 116, 112, 108, 100, 96, 92, 88, 86, 84, 78, 74, 72, 66, 64, 60, 58, 52, 50, 36, 34, 32, 30, 18
.05–.50	Following height growth apex	212, 130, 106, 24, 104
.55–1.00	Following height growth apex	166

FIGURE 90. Distribution of 67 boys by case numbers according to time relation of leg length growth apex to height growth apex. 0 indicates simultaneous occurrence. Years to the left indicate leg length growth apex prior to height growth apex; years to the right indicate leg length apex following height growth apex.

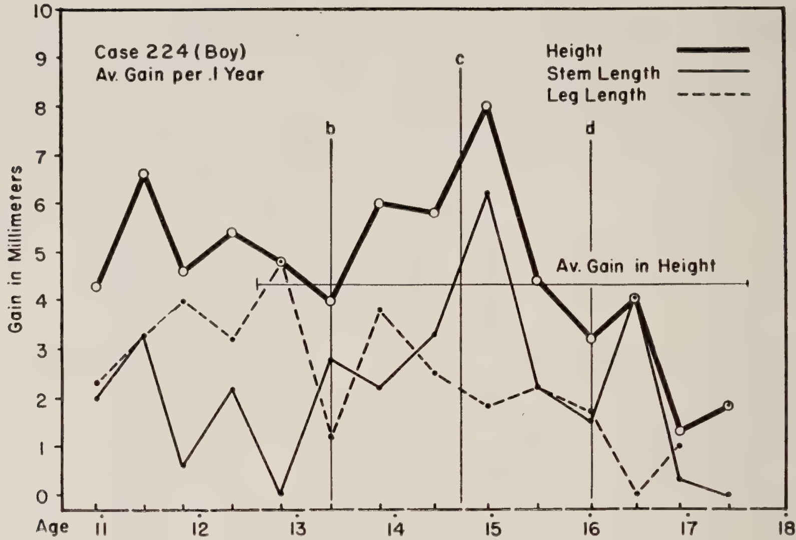


FIGURE 91a. Growth curves for boy (Case 224) illustrating time relation between leg length apex and height apex. Leg length apex occurred 2.1 years prior to height apex. In 8.95 per cent of the 67 cases leg length apex preceded height apex by 2 or more years. This curve also illustrates the 13.43 per cent cases in which leg length apex preceded onset of the puberal period for height.

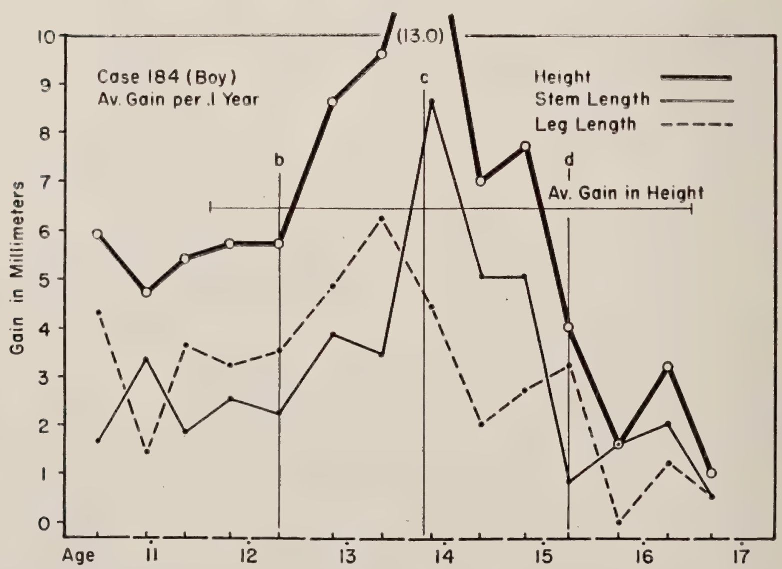


FIGURE 91b. Growth curves for boy (Case 184) illustrating time relation between leg length apex and height apex. Leg length apex occurred .5 year prior to height apex. Of the 67 cases, 8.95 per cent had similar timing.

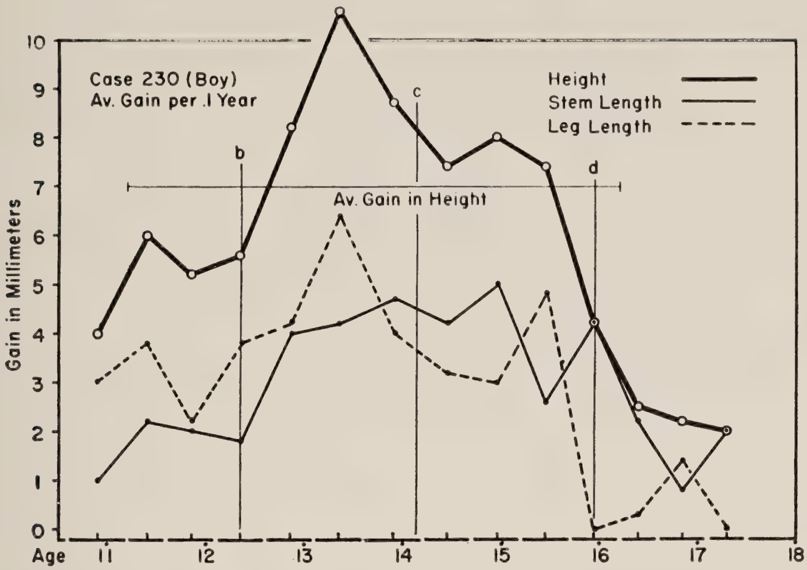


FIGURE 91c. Growth curves for boy (Case 230) illustrating simultaneous timing of leg length and height apexes. Of 67 cases, 56.72 per cent had similar timing.

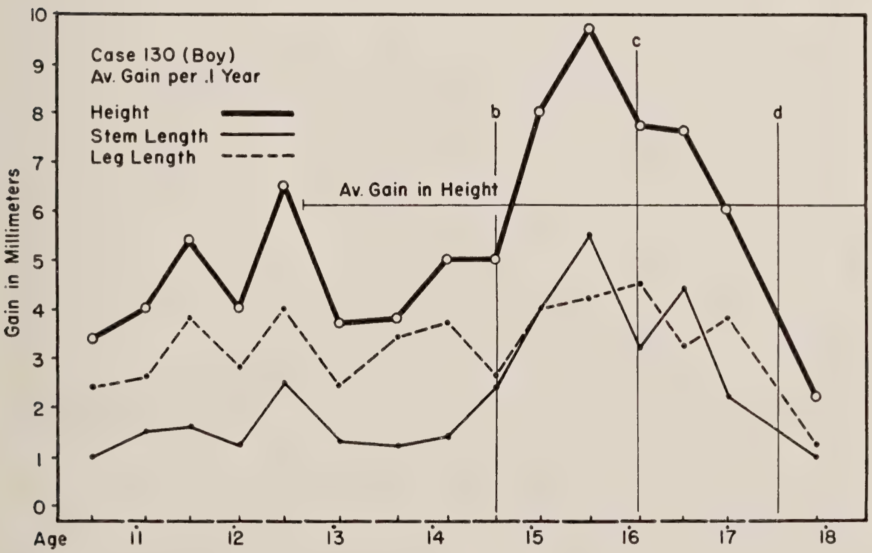


FIGURE 91d. Growth curves for boy (Case 130) illustrating leg length apex following height apex by .5 year. Only 7.46 per cent of the cases had similar timing.

In almost three fifths of the cases the apex for leg length and for height were synchronous. However, in the remaining two fifths of the cases the range of leg length asynchrony was from 3.5 years before to 1.05 years after the height apex. We find a greater tendency for leg length apex to precede height apex than to follow it (34.33 per cent compared with 8.95 per cent).

That there is a strong tendency toward the coincidence of puberal growth velocity in leg length and in height is indicated by the fact that in about three cases out of four (73.13 per cent) they occurred either simultaneously or within six months of each other.

Figures 91a, b, c, and d illustrate variations in degree of apex synchrony between leg length and height during the puberal growth period.

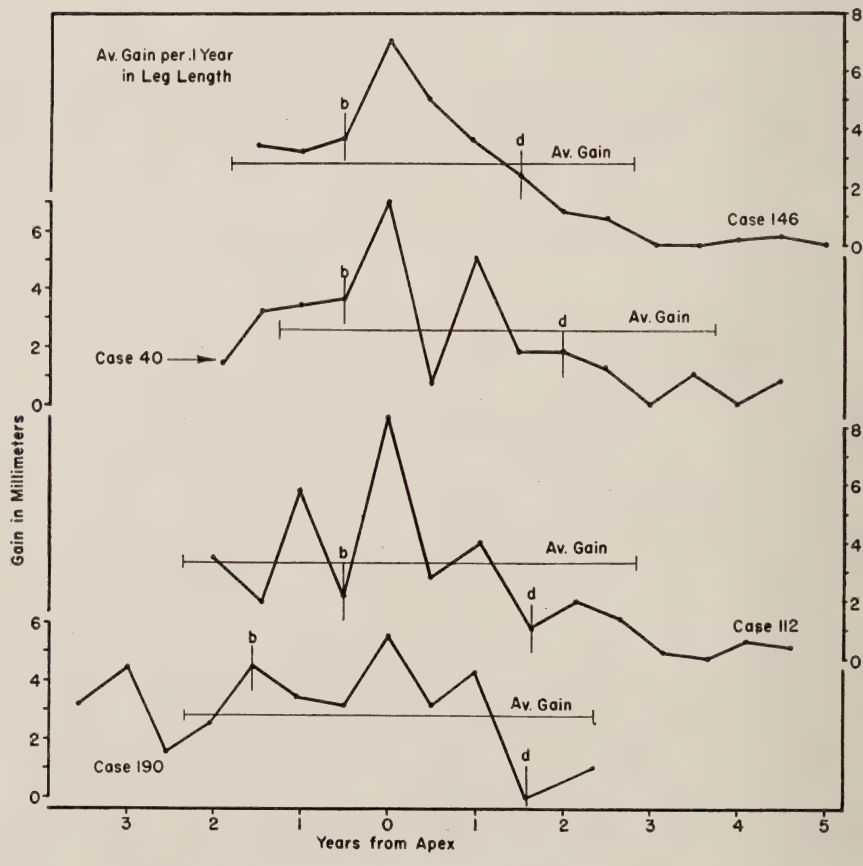


FIGURE 92. These four profiles of leg length growth illustrate the variation among individuals in the incidence of major peaks. That for Case 40, with two major peaks, was the most common (32 cases, or 47.76 per cent) for our sample.

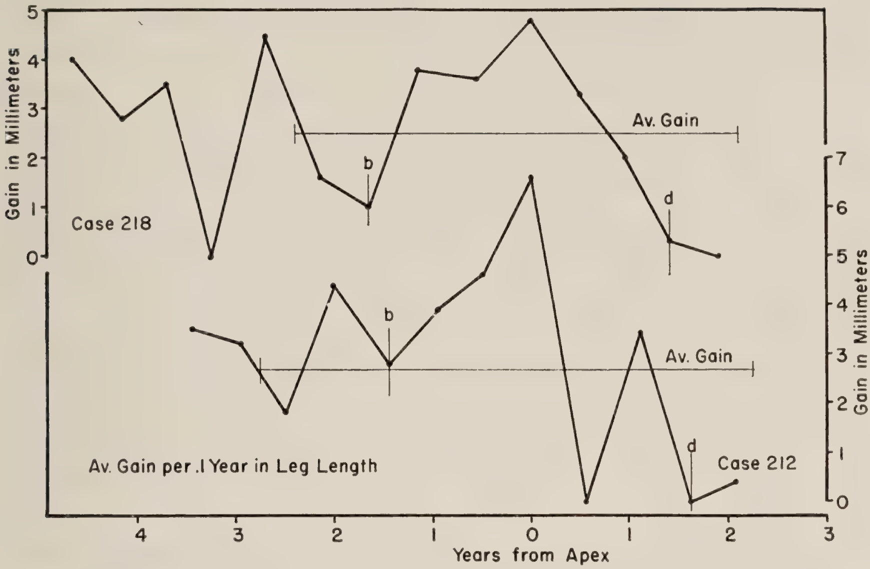


FIGURE 93. These are two of the six leg length growth profiles in which a major dip occurred during adolescence. In Case 218 the dip came during the prepuberal period; in Case 212 it occurred late in the puberal period.

CONFIGURATION OF GROWTH PROFILE FOR LEG LENGTH

In general, leg length profiles parallel height profiles rather consistently during the prepuberal period and from the onset of the puberal period to the apex for height. From the latter point to the end of the postpuberal period the profile line for leg length tends to fall more precipitously than the height line.

The profiles for all 67 of our sample show that leg length growth velocity tends to vary more frequently and more widely from one six month period to the next than does stem length growth velocity. This is borne out by analysis of the frequency with which major peaks occur.[13] In our sample the range of frequency for the group was from 1 to 4; the mean was 2.37 per case. In 5 cases (7.46 per cent) the puberal apex was the only major peak; in 36 cases (53.73 per cent) there were two major peaks; in 22 cases (32.83 per cent) there were three; in 4 cases (5.97 per cent) there were four. Profiles illustrating these several patterns are shown in Figure 92.

Despite the greater frequency of major peaks there were only six cases which showed major dips in the leg length profile, as against nine for stem length. In four of the six cases the major dip occurred during the prepuberal period; in the other two it occurred late in the puberal period for

height. In Figure 93 are shown two profiles which illustrate this difference in timing.

SUMMARY

The growth of length in stem and the growth of length in legs during adolescence show interesting dissimilarities. Measurements for the 67 boys were analyzed at the four developmental points: a year and a quarter before the onset of the puberal period, at onset and end of the puberal period, and a year and a quarter after the puberal period.

In general, stem length grows less in the prepuberal and in the first half of the puberal period and more in the second half of the puberal and in the postpuberal period than leg length. The mean for stem length was greater at each developmental point than for leg length, the least difference being at the puberal onset, and the greatest difference occurring during the postpuberal period.

The distributions, however, showed a wide range of variation at each point for both stem length and leg length. In comparison with height, variation was less for stem length and greater for leg length at the four developmental points. In stem length and leg length, variation steadily decreased with maturity, but the decrease was more marked in leg length.

Although the difference between the shortest and longest legs increased with degree of maturity, the middle fifty per cent gradually came closer to the mean, so that the general variation among the group became less. Stem length showed no such tendency. Both the range and interquartile range were least at the onset, the total range was greatest at the end of the puberal period, the interquartile range greatest during the postpuberal period.

There seemed to be a strong tendency for boys who were short-stemmed during the prepuberal period to remain consistently short-stemmed; among the long-stemmed boys the positional pattern was much less consistent. In leg length the situation was reversed; the tendency for the same boys to remain short-legged was not as great as the tendency to remain long-legged. In stem length/height ratio the consistency of the position of individual boys in the group at the four determinations was high.

The average puberal gain in stem length was 112.24 millimeters (4.41 inches) which exceeded the average gain in leg length by 12.75 millimeters (.502 inch). In percentage gain, stem length exceeded the average 13.50 per cent gain in leg length by 1 per cent. However, there were some boys who gained more in leg length than in stem length, and three boys who made higher percentage gains in leg length than any boy made in stem length. There was a high correlation between actual and percentage gains in both measurements.

A comparison of the gains in stem length and leg length with the gains during the prepuberal and postpuberal periods shows that for each measurement the mean gain during the puberal period exceeded the mean gains in the other two periods combined in the ratio of 11 to 5.

Younger boys tended to gain more in leg length (r. —.621), but this tendency was much less evident in stem length (r. —.344). In general, the longer the duration of the puberal period the greater the gain in leg length (r. .733) and in stem length (r. .667), but for each measure there were boys who made a relatively large gain during a short puberal period.

The correlations between puberal gains and measurements at the puberal onset were all negative but low. There was a slight tendency for boys with shorter trunks to make higher percentage gains in stem length (r. —.367) and for boys with shorter legs to make higher percentage gains in leg length (r. —.345). However, an analysis of the relation of puberal gain to stem length/height ratio at the puberal onset shows that, with the exception of about seven cases, the boys who were long-waisted and short-legged at onset tended to gain more in both leg length and stem length than those who were shorter-waisted and longer-legged. But the correlations were not high, and there were boys whose developmental pattern was not consistent with these general trends.

The boys varied in stem length/height ratio from .488 to .541 in the prepuberal period and from .495 to .554 in the postpuberal period. There was very little change in the means throughout adolescence. The consistency of the position of individual boys in the group at the four determinations, as has been mentioned, was high. This was probably due to the fact that the growth curve for stem length/height ratio was quite uniform. The curve in general had the following characteristics: from the prepuberal period deceleration to a dip during the first half of the puberal period, followed by a rise to the end of the puberal period. In the postpuberal period the curve is less uniform: sometimes the rise continues, sometimes it continues with a drop at the end, sometimes there is a rhythm of slight accelerations and decelerations. However, within this general framework there were many diverse individual patterns.

The puberal period for height includes the stem length apex in 98.51 per cent of the cases and the leg length apex in 86.57 per cent of the cases. The remaining one case for stem length followed the puberal period, while the remaining nine cases for leg length preceded the puberal period. There was a stronger tendency for leg length apex to be synchronous with height (56.72 per cent) than for stem length (34.33 per cent). However, there was a strong tendency for both apexes to occur within .5 of a year of the height apex: for stem length 67.16 per cent, for leg length 73.13 per cent.

The remaining cases showed asynchrony from 1.5 years preceding to 3.05 years after the height apex for stem length and from 3.5 years before to 1.00 year after for leg length.

The general characteristics of the profiles of stem length and leg length growth curves show definite differences. Stem length shows an upward trend preceding the onset, but during the first part of the prepuberal period the profile line usually dips more sharply than does the height curve, while in the postpuberal period it closely parallels the height line. The number of major peaks varied from one to four, 31.34 per cent having only the apex and 46.27 per cent having one major peak in addition to the apex. The nine cases of major dips all occurred during the prepuberal period.

The leg length profiles, in general, parallel height profiles during the prepuberal period and first half of the puberal period but tend to fall more precipitously than the height line after the apex. Leg length profiles fluctuate up and down from one examination to the next more frequently than do stem length profiles. The range of frequency of major peaks is the same for leg length as for stem length, but the average is greater (2.37 per case) for leg length. There were 53.73 per cent with two major peaks and 32.83 per cent with three major peaks. However, there were fewer cases which showed a major dip.

The outstanding characteristic of the individual curves for both stem length and leg length growth is the idiomatic nature of each boy's growth within a pattern common to the majority of boys. Each boy's curve shows some, though not necessarily all, of the features of this generalized pattern.

FOOTNOTES FOR CHAPTER VI

[1] Measurements were also made of sitting height, as described on page 18. We have used stem length for this analysis because it is more nearly a measurement between bony points; the sitting height measurement includes a greater soft tissue component.

[2] Complete data for this section will be found in Appendix I.

[3] See page 87.

[4] Complete data for the 67 boys upon which this discussion is based will be found in Appendix J.

[5] One boy, Case 220, made his highest gain at two consecutive examination periods; his age at the mid-point between examinations was taken as the apex age.

[6] For the definition of major peaks and major dips, see page 114 in Chapter V.

[7] For a complete tabulation by cases of the incidence of major dips and peaks occurring during the adolescent period, see Appendix H.

[8] See discussion of stem length/height ratio at onset and percentage gains in stem length on page 127 and scatter diagram on page 128.

[9] Complete data for 67 boys upon which this section is based will be found in Appendix K.

[10] Case 236 was a boy who passed through a marked fat period and showed a

delayed onset of the puberal growth period, as defined. His peculiar pattern will be discussed later.

[11] See pages 87 and 125.

[12] Complete data for the 67 boys upon which this discussion is based will be found in Appendix J.

[13] See page 114 for description of major peaks and dips.

Chapter VII GROWTH IN BODY WIDTH DURING ADOLESCENCE

As boys grow up they increase not only in skeletal length but also in skeletal width. In previous chapters we have considered growth in total body length (height) and growth in the length of specified segments (stem length and leg length). In this chapter we will present our findings concerning growth in body width in relation to the puberal growth period for height.

Three measurements of body width were taken regularly at each examination: measurements of biacromial width, bi-iliac width, and bitrochanteric width.[1] We have used the data from the measurements of biacromial and bi-iliac width as a basis for studying changes in width growth during adolescence. Bitrochanteric width is largely a measure of pelvis width and therefore correlates highly with the bi-iliac diameter. As between the two measures, bi-iliac width is slightly more reliable.

The reliability of the biacromial measurements as between two examiners is high.[2] However, the biacromial width is the least satisfactory of the skeletal measurements we have used. This is because the position in which the shoulders are held can significantly affect the measurement. In spite of this, the following analysis shows that definite patterns of growth emerge from our data.

Section A GROWTH IN SHOULDER WIDTH

MEASUREMENTS AT DEVELOPMENTAL POINTS

The measurements for shoulder breadth as determined for the group at the four developmental points are summarized in Table 35.[3] In the prepuberal period (Point b — 3) the mean of the biacromial measurements for our 67 boys was 305.08 millimeters (12.01 inches). Between the boy with the least and the boy with the greatest breadth there was a difference of 90 millimeters (3.54 inches). As will be seen in Figure 94a, the distribution of cases according to shoulder breadth at b — 3 is quite symmetrical and compact except for the three cases with the greatest breadth. It will be noted that the range during the prepuberal period overlaps the range during the postpuberal period. This overlapping was due to the shoulder breadth

Table 35 GROWTH IN SHOULDER BREADTH (BIACROMIAL DIAMETER) IN RELATION TO THE PUBERAL GROWTH PERIOD FOR HEIGHT—67 BOYS

A. In Millimeters

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3	*Coefficient of Variation*
Prepuberal (b − 3)	273–363	305.08	15.60	306.04	295.75	314.03	5.11
Onset of puberal (b)	282–369	317.97	15.15	318.40	310.47	326.80	4.76
End of puberal (d)	335–425	369.55	16.38	371.04	359.11	379.53	4.16
Postpuberal (d + 3)	355–445	383.32	17.17	386.11	377.19	397.50	4.48
Puberal gain (b–d)	25–80	51.59	11.18	52.80	44.70	56.90	

B. In Inches

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3	*Coefficient of Variation*
Prepuberal (b − 3)	10.75–14.29	12.01	.61	12.05	11.65	12.36	
Onset of puberal (b)	11.10–14.52	12.51	.60	12.53	12.22	12.87	
End of puberal (d)	13.19–16.74	14.54	.64	14.57	14.13	14.94	
Postpuberal (d + 3)	13.98–17.52	15.09	.68	15.20	14.86	15.65	
Puberal gain (b–d)	.95– 3.15	2.03	.44	2.08	1.76	2.24	

at b — 3 of only one boy (Case 236), a late developer who had a long prepuberal period followed by a short puberal period. By the close of the puberal period he was no longer in an extreme position, though still a broad-shouldered boy.

At the onset of the puberal growth period for height, the mean had increased to 317.97 millimeters (12.51 inches) and the range between the narrowest and the broadest showed a difference of 87 millimeters (3.42 inches), slightly less than at the previous determination. Only one case (236) fell noticeably outside the rather compact grouping shown in Figure 94b.

At the end of the puberal growth period the mean for the biacromial diameter was 369.55 millimeters (14.54 inches), and the difference between the least and the greatest measurements was again 90 millimeters

Millimeters	270	275	280	285	290	295	300	305	310	315	320	325	330	335	340	345	350	355	360
									134										
									112										
								154	32										
								104	116	34									
								84	68	176									
								110	168	184	52								
					92			36	230	180	234								
					136	164	242	96	44	8	146								
					304	100	80	294	220	218	166								
					88	86	120	190	206	130	250	106							
			18	244	78	64	108	150	58	144	216	26	292						
		40	82	24	212	62	30	10	50	60	54	72	66		224		74		236

FIGURE 94a. Distribution of 67 boys by case numbers according to shoulder breadth at the third examination preceding the onset of puberal growth period for height: mean, 305.08 millimeters; standard deviation, 15.60 millimeters; median, 306.04 millimeters; Q_1, 295.75 millimeters; Q_3, 314.03 millimeters.

Millimeters	285	290	295	300	305	310	315	320	325	330	335	340	345	350	355	360	365
								218									
								130									
								134									
								80									
								120									
								116	84	146							
							96	242	206	184							
							190	32	166	216							
							64	18	52	180							
					136	110	154	250	34	144							
					86	108	150	212	26	220	60						
					30	294	44	164	10	104	8						
	78		244		58	100	230	112	72	68	234	292			74		
	82	40	304	92	36	24	62	88	54	50	176	168	106	224	66		236

FIGURE 94b. Distribution of 67 boys by case numbers according to shoulder breadth at the onset of the puberal growth period for height: mean, 317.97 millimeters; standard deviation, 15.15 millimeters; median, 318.40 millimeters; Q_1, 310.47 millimeters; Q_3, 326.80 millimeters.

Millimeters	335	340	345	350	355	360	365	370	375	380	385	390	395	400	405	410	415	420	425
									146										
									72										
									104										
							176		230	18									
						120	190		164	52									
						294	108		50	106									
						130	116	250	242	10	26								
						54	100	88	218	220	8	292							
		244			110	154	44	64	212	80	66	224		180					
		304	58	92	36	30	136	112	68	62	84	206	236	166					
	40	78	82	24	96	134	86	34	32	60	184	144	150	216	234	168			74

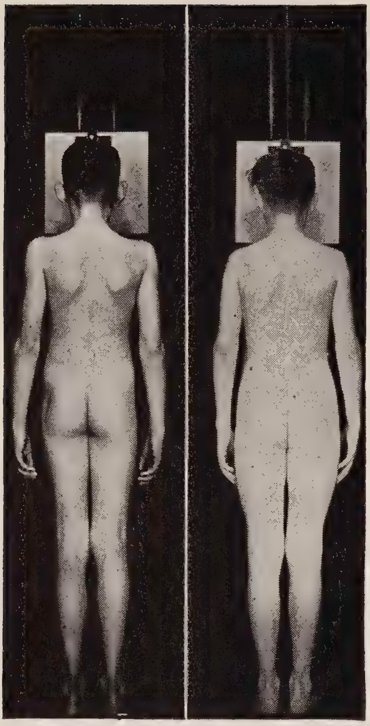
FIGURE 94c. Distribution of 67 boys by case numbers according to shoulder breadth at end of the puberal growth period for height: mean, 369.55 millimeters; standard deviation, 16.38 millimeters; median, 371.04 millimeters; Q_1, 359.11 millimeters; Q_3, 379.53 millimeters.

Millimeters	360	365	370	375	380	385	390	395	400	405	410	415	420	425	430	435	440	445
						80												
						50												
					82	176	110	66										
					116	104	108	18										
					112	60	52	220										
	92				218	250	44	146	32	224								
	304				136	88	230	100	62	150		236						
	294	24		64	86	212	84	242	206	10		166						
	78	54	134	36	190	154	72	184	68	106	292	144	234					
	40	58	244	96	30	120	34	8	164	26	216	180	168					74

FIGURE 94d. Distribution of 66 boys by case numbers according to shoulder breadth at third examination following end of the puberal growth period for height (d + 3): mean, 383.32 millimeters; standard deviation, 17.17 millimeters; median, 386.11 millimeters; Q_1, 377.19 millimeters; Q_3, 397.50 millimeters.

(3.54 inches). By this time Case 74 had emerged as a boy with exceptionally broad shoulders to match his exceptional height, while Cases 66, 236, and 224 had moved closer to the mean though still within the upper quartile of the distribution, as shown in Figure 94c.

The postpuberal distribution (at d + 3) presented in Figure 94d shows a piling up of cases at the two extremes of a rather compact grouping, disregarding Case 74. If we leave out Case 74 the range has shrunk to 60 millimeters (2.36 inches) between the broadest and the narrowest of the other 66 cases. With Case 74 included, the range is still 90 millimeters (3.54 inches), although the mean has increased to 383.32 millimeters (15.09 inches). In Figure 95 are shown photographs taken at comparable developmental points of two boys (Cases 144 and 244), one narrow-shouldered and one broad-shouldered.



Case 144 C.A. 11.3 — **Case 244** 13.2

Puberal onset

Case 144 14.3 — **Case 244** 16.6

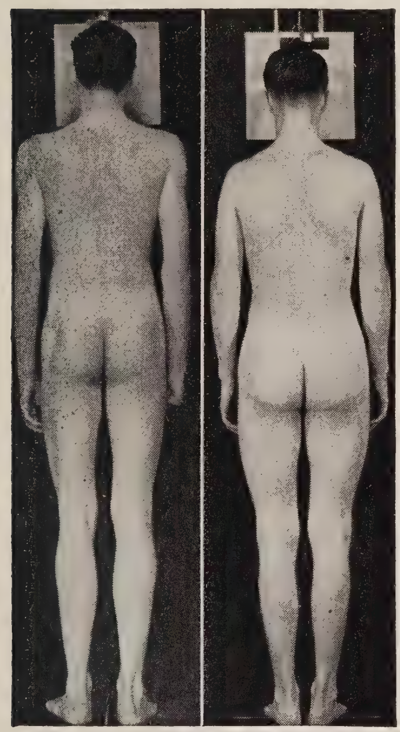
Puberal end

PUBERAL GAIN IN SHOULDER BREADTH

The average gain in shoulder breadth during the puberal period was 51.59 millimeters (2.03 inches) with a standard deviation of 11.18 millimeters (.44 inch). The average gain from b — 3 to b was approximately the same as the average gain from d to d + 3, but there was a significant increase in the variability from the prepuberal to the postpuberal periods. During the puberal period the mean gain was approximately twice the sum of the mean gains of the prepuberal and postpuberal periods. The average duration of the puberal period (2.81 years) was only slightly higher than the combined duration of the prepuberal and postpuberal periods (2.5 years).

That there were marked differences among these boys in the amount of shoulder breadth gained during the puberal period is shown by Figure 96 in which the amounts gained from b to d are distributed.

Relation of gain to duration of puberal period. Case 150 gained 80 milli-



Case 144 C.A. 15.5 **Case 244** 17.9

Postpuberal

FIGURE 95. Photographs of two boys, one narrow-shouldered and one broad-shouldered, at comparable developmental points. Case 144 was an early developer and Case 244 a late developer. The duration of the puberal period for the broad-shouldered boy was four months less than for Case 244.

								242							
								10							
								108							
								32							
								30							
								294	144						
								250	82						
						292		88	164						
						50	92	78	136						
					34	68	8	72	86						
					120	146	220	64	84						
			154	130	60	116	190	36	80	206			166		
			106	134	58	304	112	218	212	18			74		
			176	96	224	244	44	184	100	26		216	234		
	236		66	54	24	110	104	40	52	230	62	168	180		150
Millimeters	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80

FIGURE 96. Distribution of 67 boys according to gain in shoulder breadth during the puberal growth period for height: mean, 51.59 millimeters; standard deviation, 11.18 millimeters; median, 52.80 millimeters; Q_1, 44.70 millimeters; Q_3, 56.90 millimeters.

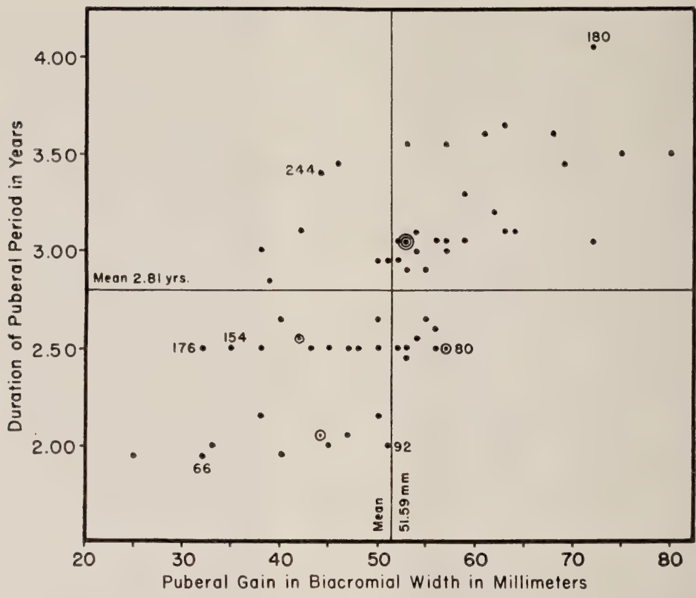


FIGURE 97. Relation between puberal gain in shoulder width and duration of the puberal growth period for height. Coefficient of correlation .673, P.E. ± .045. Note the wide differences in amount gained among cases who had the same duration. See Figure 98a for growth curves of shoulder width for Cases 66 and 92; Figure 98b for growth curves of Cases 80 and 176.

meters (3.15 inches) during this period; this was 55 millimeters (2.16 inches) more than the amount gained by Case 236. However, the duration of the puberal period for Case 150 was 3.50 years and for Case 236 only 1.95 years. As in height growth, there is a high correlation between the amount of puberal gain in shoulder breadth and the duration of the puberal period. The Pearson coefficient of correlation is .673, P.E. ±.045. But, as is readily seen in the scatter diagram in Figure 97, there are many examples of similar duration and wide variation in gain, as well as examples of similar gain and wide variation in duration. Several examples of these contrasts are presented in the curves in Figures 98a and b.

Relation of puberal gain to postpuberal width. In general, the boys who were destined to have the broadest shoulders made the greatest gains, and the boys destined to have the narrowest shoulders made the least gains during the puberal growth period. The relation between the gain in shoulder breadth during the puberal period and shoulder breadth at d + 3 is shown in the scatter diagram in Figure 99. The Pearson coefficient of correlation is .428, P.E. ±.068. There are six boys who gained less than might be expected: Cases 154, 176, 66, 106, 244, and 292.

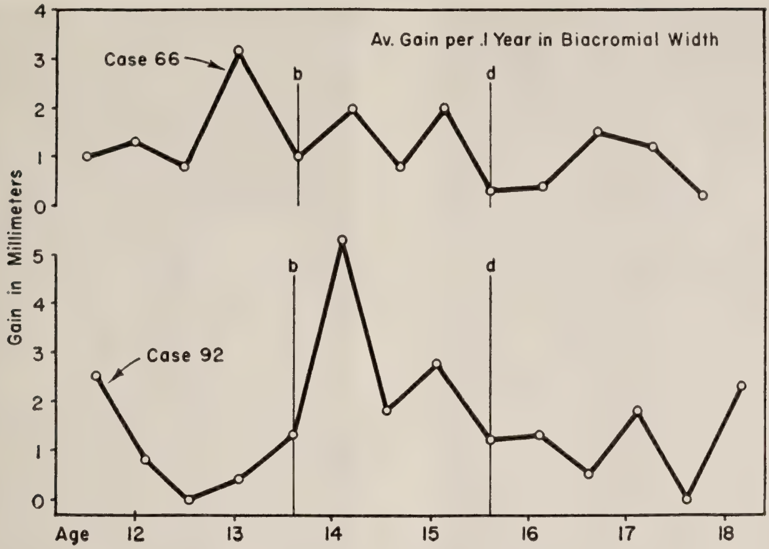


FIGURE 98a. Growth velocity profiles of shoulder breadth for two boys with similar timing, one of whom made relatively little gain in the dimension during the puberal period of height and the other of whom made average gain. Case 66 gained 32 millimeters (1.26 inches) while Case 92 gained 51 millimeters (2.01 inches) in biacromial measurements during the puberal period of height. Case 66 was broader at the onset by 55 millimeters (2.6 inches), but Case 92 gradually diminished this difference to 31 millimeters (1.22 inches) at the final examination.

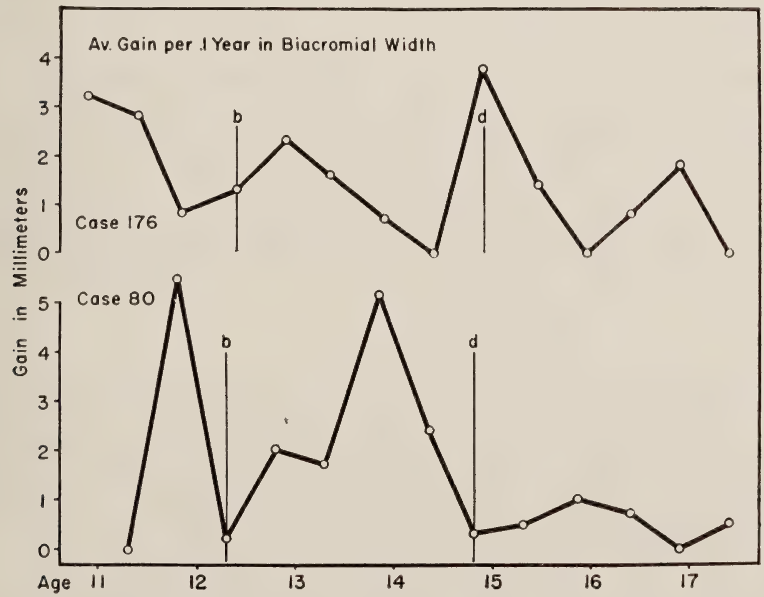
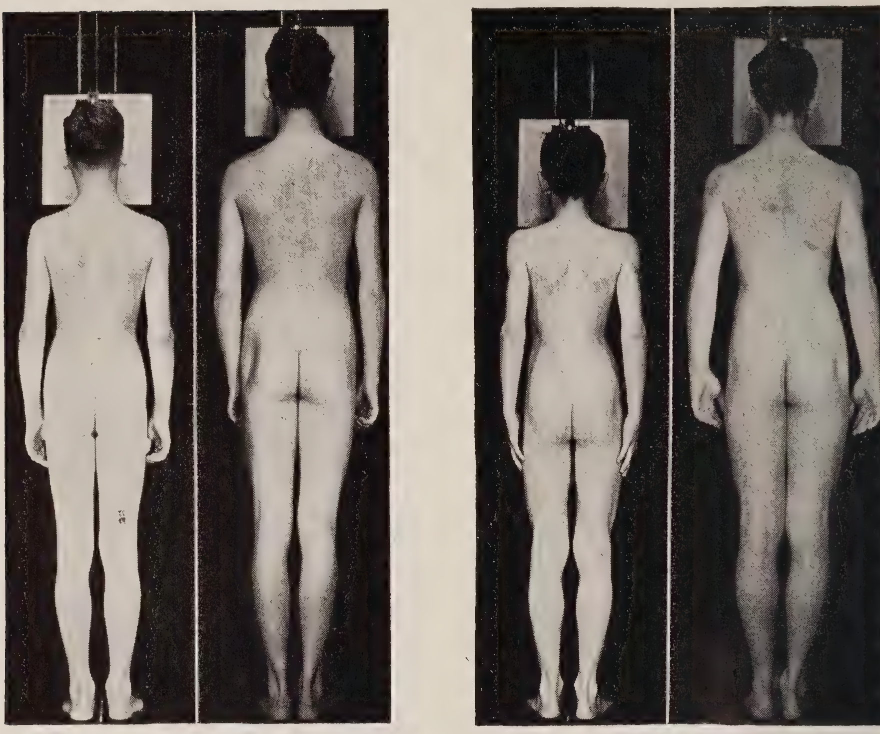


FIGURE 98b. Growth velocity profiles of shoulder width of two boys, one of whom gained 32 millimeters (1.26 inches) and the other of whom gained 57 millimeters (2.24 inches) during the puberal growth period of height. The duration was the same for both boys, 2.5 years, the mode for the group. See photographs, Figure 98c.



Case 176

C.A. 12.4 — 12.9
Onset — End

Puberal growth period

Case 80

12.3 — 15.3
Onset — End

Puberal growth period

FIGURE 98c. Photographs of the two boys whose curves are in Figure 98b (Cases 80 and 176). Illustrations of extreme differences in puberal gain in shoulder width. The growth of Case 176 who made an unusually small gain in shoulder width was atypical in other respects also; notably, his relatively low-level growth in height during the puberal period and his apex in stem length occurring in the postpuberal period. (See Figure 63b.)

Two of these boys made their maximum gain in shoulder width *after* the puberal period (Cases 154 and 106). One of them made his maximum gain before the puberal period (Case 292).[4] The other three cases all had long prepuberal periods with puberal periods relatively undifferentiated from the prepuberal (Cases 66, 176, 224).[5] See Figure 100.

There were some instances in which boys who were placed near the mean in shoulder width for the group at b showed marked divergence in amount of relative growth during the puberal period. In Figure 101 we show photographs of two such boys.

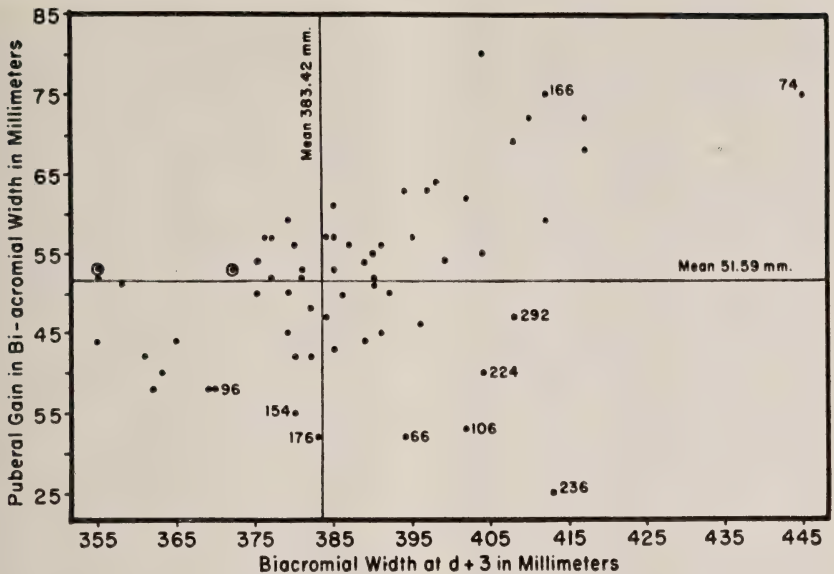


FIGURE 99. In general, the boys who had the broadest shoulders in the postpuberal period were the ones who gained most during the puberal period. Coefficient of correlation was .428. Six cases made relatively less gains than might have been expected. Cases 154 and 106 made maximum gains in the postpuberal period, Case 292 in the prepuberal period.

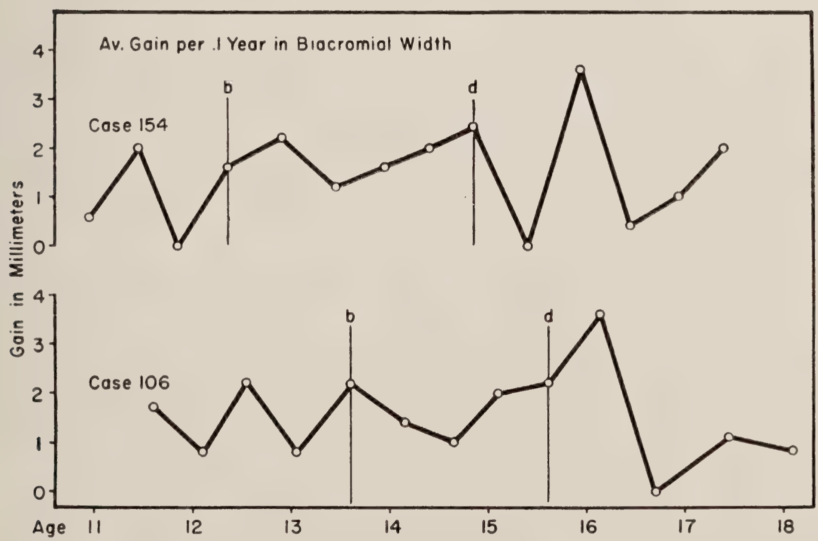
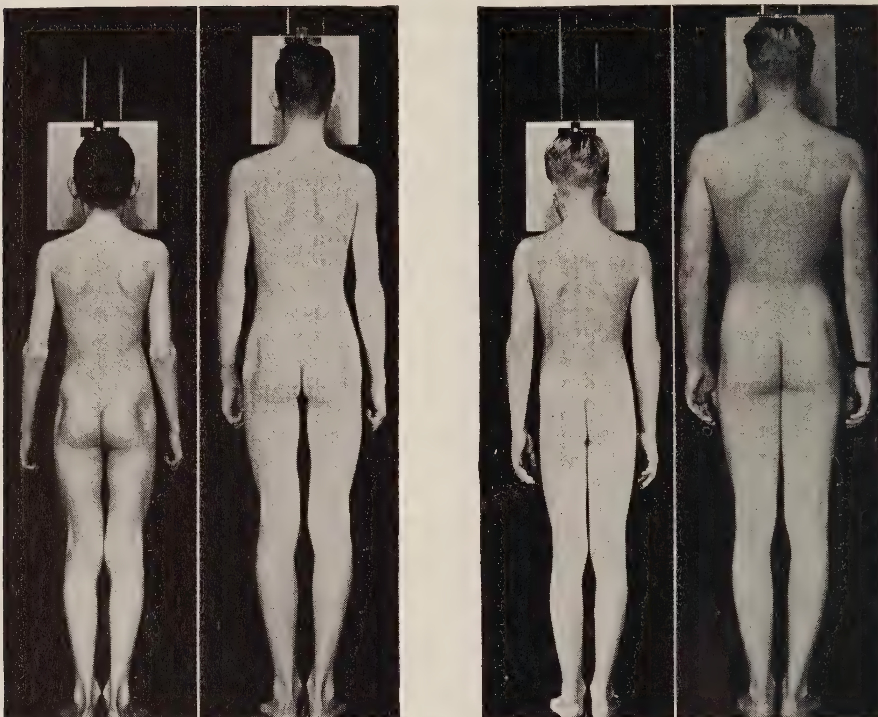


FIGURE 100. These two boys made relatively small gains in shoulder width during the puberal period because the apex of growth for each occurred during the postpuberal period. Case 106 was a broad-shouldered boy, Case 154 about average.



Case 96

C.A. 12.5 Onset — 15.0 End

Puberal growth period

Case 166

12.8 Onset — 16.3 End

Puberal growth period

FIGURE 101. At the onset of the puberal period for height (b) Case 96 had shoulder breadth 4 millimeters below the mean for the group, and Case 166 was 4 millimeters above the mean. At the end of the puberal period (d) Case 96 was 7 millimeters below Q_1, while Case 166 was 17 millimeters above Q_3. The actual difference between their gains was 37 millimeters (1.46 inches). The two boys began the puberal period only three months apart, but the duration of the period was a year longer for Case 166.

TIMING RELATIONS BETWEEN GROWTH APEXES FOR SHOULDER BREADTH AND FOR HEIGHT

Increases in shoulder breadth in relation to height are important indices not only of the stage of maturity but also of changes in body build. Knowledge of the timing of growth in shoulder width is essential in the consideration of either of these matters.[6]

Our first analysis was made to discover whether the apex of growth in shoulder breadth occurred within the puberal growth period of height as defined in Chapter IV.[7] We found that in 51 of the 67 cases (76.05 per cent) the shoulder growth apex occurred within the puberal growth period;

in 9 cases it occurred prior to the onset of the period; in 7 cases it occurred after the close of the period.

We next compared the timing of the apex of growth in shoulder width with the apex of growth in height. In only ten cases (14.9 per cent) were these two apexes synchronous. In over one third of the cases the greatest acceleration in shoulder width growth came before the apex for height. In slightly less than half of the cases it came after the apex for height.

In one case apex acceleration for shoulder width growth occurred 3.55 years before the apex for height and in two cases 3.05 years after the apex for height. In these cases the apex for biacromial growth was outside of the period of puberal growth in height.

However, the tendency toward coincidence of maximum acceleration for shoulder width and for height growth is indicated by the finding that in almost forty per cent of the 67 cases the apex for biacromial width occurred within .5 of a year of the apex for height.

The timing relations between maximum growth velocity for these two diameters of the body are summarized in Table 36.

Table 36 TIMING RELATIONS OF BIACROMIAL GROWTH APEX TO HEIGHT GROWTH APEX AND THE PUBERAL PERIOD

Relation of Biacromial Apex	*Number of Cases*	*Per Cent of 67 Cases*	*Year Difference* Average	Range
Synchronous with height apex	10	14.92		
Preceding height apex	24	35.82	1.40	3.55– .50
Preceding puberal onset	9	13.43	2.26	1.15– 3.55
Preceding height apex but within puberal growth period	15	22.39	.83	.50– 1.50
Following height apex	33	49.25	1.16	3.05– .25
Following end puberal period	7	10.45	2.17	1.00– 3.05
Following height apex but within puberal period	26	38.80	.88	.25– 1.90
Within ±.5 year of height apex	26	38.80		
Within puberal period for height	51	76.05		

Specimen individual curves illustrating the variations in timing relationship are shown in Figures 102a, b, and c.

THE CONFIGURATION OF THE GROWTH PROFILE FOR SHOULDER WIDTH

The great variability in rate of growth during the adolescent years is, perhaps, the outstanding impression one receives from the inspection of the growth profiles for shoulder width. There are marked individual differ-

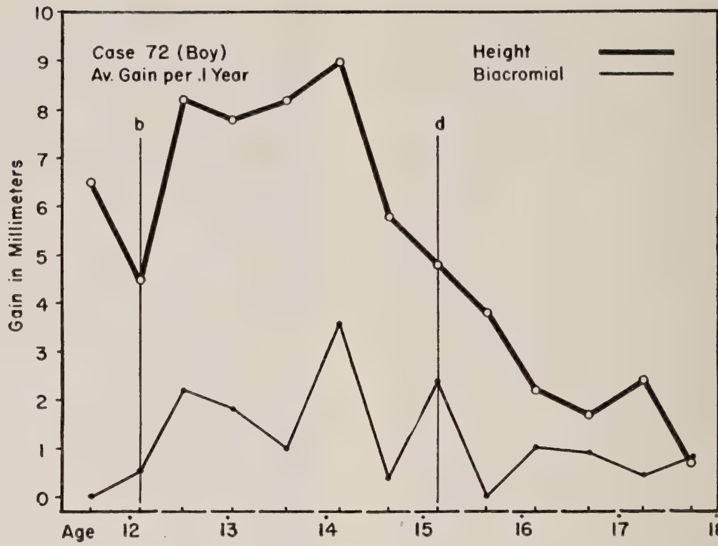


FIGURE 102a. Growth curves of a boy (Case 72) in which apex growth of biacromial width and of height are synchronous. Ten cases (14.92 per cent) had similar timing.

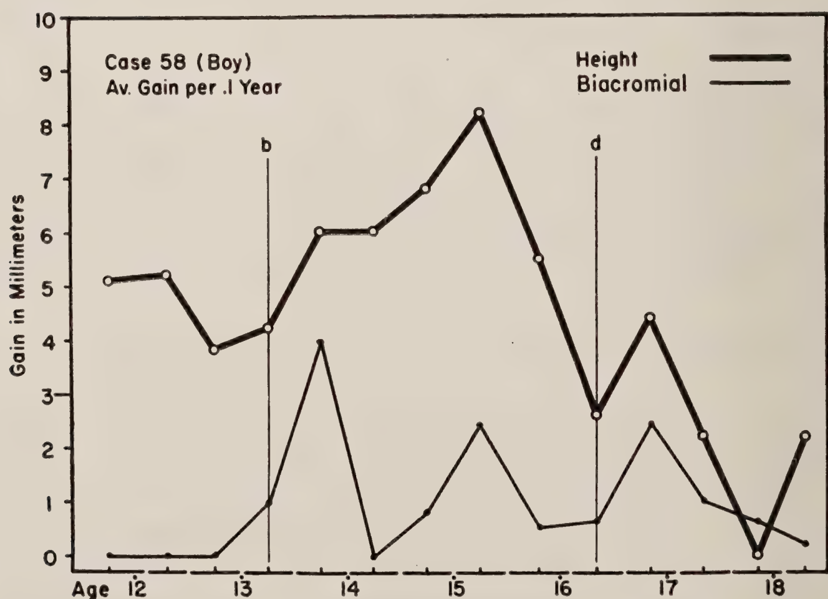


FIGURE 102b. Growth curves of a boy (Case 58) where apex growth of biacromial width precedes apex for height growth. Twenty-four cases (35.82 per cent) had similar timing.

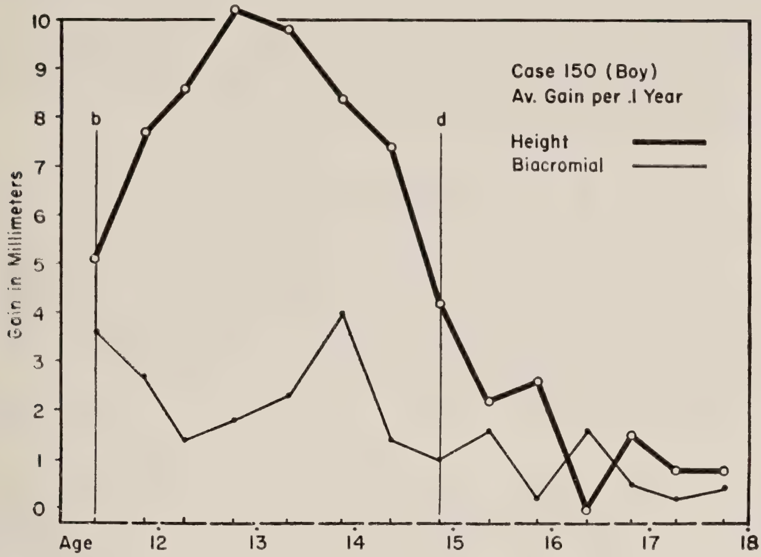


FIGURE 102c. Growth curves of a boy (Case 150) where apex of biacromial growth follows apex of height growth. Thirty-three cases (49.25 per cent) had similar timing.

ences in the spacing of the major peaks and in the timing relations of these peaks to the specific developmental points on the height growth profiles. The tendency for six month alternations of peaks and dips in the profile line is more marked than for any other of the skeletal growth profiles which were studied.

This impression is supported by an analysis of the frequency with which major peaks and major dips occur in the 67 profiles.[8] Major peaks occurred more than twice as frequently in the shoulder width profiles as in the height profiles, the average number per case being 3.54. The range of frequency for major peaks in shoulder breadth was from 1 to 5 and the range for major dips from 0 to 4. In the profiles for shoulder width there were a good many peaks which rose only slightly above the line of average gain for the five year period, and this made the formula for discriminating between major and minor peaks less satisfactory than for any of the other profiles. Major dips occurred on the average of 1.45 per case, as compared to an average of .015 for height.

It might be assumed that the frequency of major dips and peaks in the growth curves of biacromial width, as well as the minor fluctuations, are due to the inevitable fallibility of measurement when growth changes are comparatively slight. We have given this possibility serious consideration. In view of the high reliability of the measurements (see Tables 2, 3, and 4

in Chapter III) we are convinced that these fluctuations are primarily the expressions of the normal pulse or rhythm of growth. The general similarity of contours of biacromial growth among the hundred boys in our study would seem to support this conviction.

Section B GROWTH IN HIP WIDTH

HIP WIDTH MEASUREMENTS AT DEVELOPMENTAL POINTS

The hip width (bi-iliac diameter) measurements for the group are summarized in Table 37.[9] The distribution of the 67 cases at the four developmental points are presented in Figures 103a, b, c, and d.

In the prepuberal period (Point b — 3) the mean hip width (bi-iliac

					244									
					206		216	36						
			30	96	60	26	50	168						
			10	86	212	296	54							
			82	32	190	84	144	164						
			78	242	166	80	120	150						
			64	110	234	44	104	8		250				
			72	24	230	18	58	176	106	88		236		
		304	62	154	184	218	34	112	68	146		66		
		40	92	116	100	136	220	108	52	134	292	130	224	74
Millimeters	205	210	215	220	225	230	235	240	245	250	255	260	265	270

FIGURE 103a. Distribution of 67 boys according to hip width at the third examination preceding the puberal growth period for height: mean, 229.16 millimeters; standard deviation, 13.65 millimeters; median, 228.43 millimeters; Q_1, 219.22 millimeters; Q_3, 237.92 millimeters.

					244								
					218								
					212	144							
					32	34							
					206	180							
					100	136		104					
					26	294		168					
			242		24	184	108	112					
			64	18	190	150	8	68					
			10	154	110	84	176	216					
			116	72	80	44	220	52					
			92	30	78	234	130	36		146			224
			86	230	166	60	54	164	88	250			66
	40	304	62	96	82	58	120	50	106	134	292	236	74
Millimeters	210	215	220	225	230	235	240	245	250	255	260	265	270

FIGURE 103b. Distribution of 67 boys according to hip width at onset puberal growth period for height: mean, 238.33 millimeters; standard deviation, 12.30 millimeters; median, 236.88 millimeters; Q_1, 230.62 millimeters; Q_3, 246.25 millimeters.

						244								
						220								
						144								
						176								
						104								
						34								
						218								
					82	206	216							
				58	230	184	136							
				72	84	150	36		224					
			62	60	130	120	212	250	68	66				
		64	86	78	32	100	8	108	26	88				
	92	242	154	30	166	54	294	146	236	292				
	40	24	116	110	190	112	234	106	180	168				
	304	10	96	18	44	80	50	52	164	134				74
Millimeters	245	250	255	260	265	270	275	280	285	290	295	300	305	310

FIGURE 103c. Distribution of 67 boys according to hip width at end of puberal growth period for height: mean, 271.61 millimeters; standard deviation, 12.50 millimeters; median, 272.03 millimeters; Q_1, 263.40 millimeters; Q_3, 280.25 millimeters.

							82									
							34									
						244	230									
						84	206									
						58	120		250	236						
						110	112		216	108						
				86	78	30	80	54	106	66						
				18	60	44	294	176	100	26						
				154	116	218	220	36	52	224	168					
				96	62	190	184	212	50	180	134					
	304			64	242	166	104	234	144	136	164					
	40		92	10	24	72	32	150	8	68	146	88	292			74
mm	250	255	260	265	270	275	280	285	290	295	300	305	310	315	320	325

FIGURE 103d. Distribution of 66 boys according to hip width at third examination following the end of the puberal growth period for height: mean, 279.81 millimeters; standard deviation, 14.67 millimeters; median, 278.64 millimeters; Q_1, 270.75 millimeters; Q_3, 289.69 millimeters.

diameter) for our group of 67 boys was 229.16 millimeters (9.02 inches). At that time the boy with the widest hips exceeded the boy with the narrowest by 61 millimeters (2.41 inches), the range being from 208 millimeters (8.18 inches) to 269 millimeters (10.59 inches). The distribution of the cases, shown in Figure 103a, is compact and fairly symmetrical. Among the cases furthest from the mean are several who will be recognized as having been similarly placed in the corresponding distributions for height, shoulder breadth, and other dimensional measurements (Cases 74,

Table 37 GROWTH IN HIP WIDTH (BI-ILIAC DIAMETER) FOR 67 BOYS IN RELATION TO THE PUBERAL GROWTH PERIOD FOR HEIGHT

A. In Millimeters

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3	*Coefficient of Variability*
Prepuberal (b − 3)	208–269	229.16	13.65	228.43	219.22	237.92	5.96
Onset of puberal (b)	214–274	238.33	12.30	236.88	230.62	246.25	5.16
End of puberal (d)	245–314	271.61	12.50	272.03	263.40	280.25	4.60
Postpuberal (d + 3)	246–325	279.81	14.67	278.64	270.75	289.69	5.24
Puberal gain (b–d)	15–55	33.28	6.98	33.62	29.69	38.64	

B. In Inches

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3	*Coefficient of Variability*
Prepuberal (b − 3)	8.18–10.59	9.02	.54	8.99	8.63	9.36	
Onset of puberal (b)	8.43–10.79	9.38	.48	9.33	9.08	9.70	
End of puberal (d)	9.65–12.36	10.69	.49	10.71	10.38	11.03	
Postpuberal (d + 3)	9.69–12.80	11.01	.58	10.97	10.66	11.40	
Puberal gain (b–d)	.59– 2.17	1.31	.27	1.32	1.17	1.52	

224, 236, and 66 at the upper end and Cases 40, 92, and 62 at the lower end).

At the onset of the puberal growth period for height (b) the mean had increased by 9.17 millimeters (.36 inch) to 238.33 millimeters (9.38 inches). The range of difference was practically the same between the widest hipped boy and the narrowest. The several cases with unusual growth patterns are still closely grouped at the extreme position in the upper quartile. (See Figure 103b.)

At the end of the puberal growth period (d) the mean had increased to 271.61 millimeters (10.69 inches), a gain of 1.31 inches from b to d. The range of difference among our boys had increased to 69 millimeters (2.71 inches); without Case 74 the range would have been only 48 millimeters (1.89 inches).

In the distribution in the postpuberal period (at Point d + 3) shown in Figure 103d, Case 74 is still separated from the group, but there is a distinct tendency for several other cases, such as Cases 88 and 292, to move into slightly more extreme positions in the distribution. The mean, 279.81 millimeters (11.01 inches), is only 8.20 millimeters (.32 inch) greater than at d.

Comparison of hip width and shoulder width variability. The growth in hip width is similar in many respects to the growth in shoulder width. In both measures there is continuous overlapping in the range at each point; even between the prepuberal and postpuberal. The variability decreases from the prepuberal point to the onset as it did for growth in shoulder breadth. For both measures the cases are most closely grouped around the mean at onset of the puberal period, with a slight increase in variability from onset to end of the puberal period and a larger increase in the postpuberal period.

However, we find by a consideration of the coefficients of variability for hip width and for shoulder breadth that hip width is relatively more variable at every developmental point. This conclusion is based on the coefficients of variation for the two measures in Table 38.

Table 38 COEFFICIENTS OF VARIATION OF HIP-WIDTH AND SHOULDER-BREADTH MEASUREMENTS

Time of Measurement	*Coefficients of Variation*	
	Shoulder Breadth	Hip Width
Prepuberal (b − 3)	5.11	5.96
Onset of puberal (b)	4.76	5.16
End of puberal (d)	4.16	4.60
Postpuberal (d + 3)	4.48	5.24

PUBERAL GAIN IN HIP WIDTH

The distribution shown in Figure 104 presents the data concerning gain in hip width during the puberal growth period (b to d). It will be noted that at the one end of the distribution Case 224 gained only 15 millimeters (.59 inch), while at the other end Case 26 gained 55 millimeters (2.17 inches) in width. These boys had practically the same hip measure during the postpuberal period. Case 224, however, had gained much of his dimension before the onset of the puberal period of development.

Millimeters	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54
											184										
									120		150										
								176	96	292	134										
								154	78	220	116		294								
								58	64	52	72		206	136							
								50	36	34	40		108	68							
								44	242	216	30		82	244							
							10	250	110	84	190	218	80	234	230						
			66		104		304	92	106	18	144	86	62	164	212						
	224		24	236	112	146	130	60	54	8	32	166	88	100	168	74		180			26

FIGURE 104. Distribution of 67 boys according to gain in hip width during the puberal growth period for height: mean, 33.28 millimeters; standard deviation, 6.98 millimeters; median, 33.62 millimeters; Q_1, 29.69 millimeters; Q_3, 38.64 millimeters.

In Figures 105a and b we show photographs and curves of two boys whose patterns of hip-width growth diverged markedly during the puberal growth period for height. In hip-width measurement both were within 5 millimeters of the mean for the group during the prepuberal period, but at d + 3 in the postpuberal period Case 84 was 3 millimeters above Q_1, while Case 180 was 2 millimeters above Q_3. During the puberal growth period (b to d) Case 84 gained 32 millimeters and Case 180 gained 49 millimeters.

Relation of gain in hip width to duration puberal period. As would be expected, there was a high correlation between the length of the puberal period and the amount of gain in hip width, a Pearson coefficient of correlation of .640, P.E. .049. This is shown graphically in the scatter diagram in Figure 106. Case 26 gained more than might have been expected, and Case 224 gained less. (See Figures 107a and b.)

Relation of puberal gain in hip width to postpuberal width. There was only a slight tendency for the boys destined to have narrow hips to gain less and the boys destined to have broad hips to gain more during the puberal period (Pearson coefficient r. .254, P. E. .078). There were a few extreme cases definitely out of line with this trend. (See Figure 108.) Cases 66, 224, and 236 are the boys with puberal periods of relatively late onset

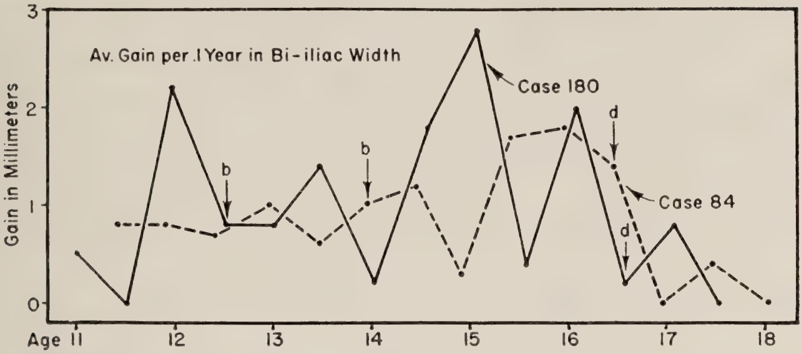
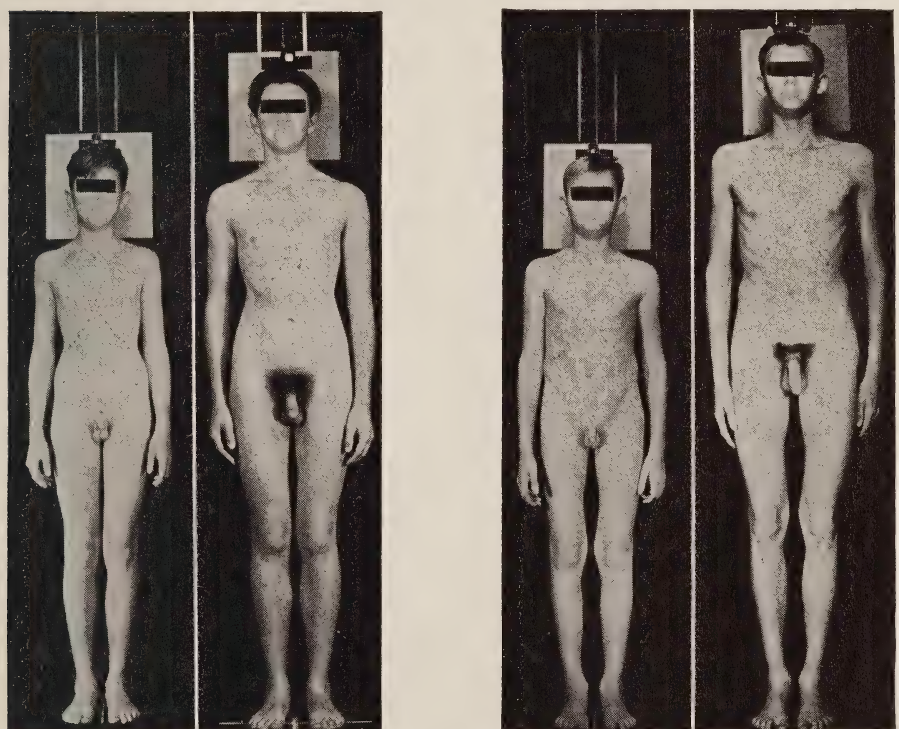


FIGURE 105a. Growth curves of the two boys whose photographs are shown in Figure 105b. Case 84 and Case 180 had the same hip width during the prepuberal period. By the postpuberal period Case 180 was 27 millimeters broader than Case 84.



	Case 84		Case 180	
C.A.	13.9	16.4	12.5	16.5

FIGURE 105b. Photographs of two boys at the onset and end of the puberal period who illustrate diverging patterns of hip-width growth during adolescence. Differences in hip width cannot be readily judged in such photographic reductions, but it is obvious that Case 180 grew more than did Case 84 in the hip-width dimension (an actual increase of 49 millimeters compared with 32 millimeters).

and short duration, discussed under biacromial measurements. Their major gains were made before the onset of the puberal period. Case 146 was among the widest-hipped boys at onset and, with an additional gain during the postpuberal period, kept his place in the group. Growth charts and photographs of Case 112, a boy with medium hips whose puberal gain was fifth from the smallest, and of Case 164, a boy with broad hips whose puberal gain was relatively large, are presented in Figures 109a and b.

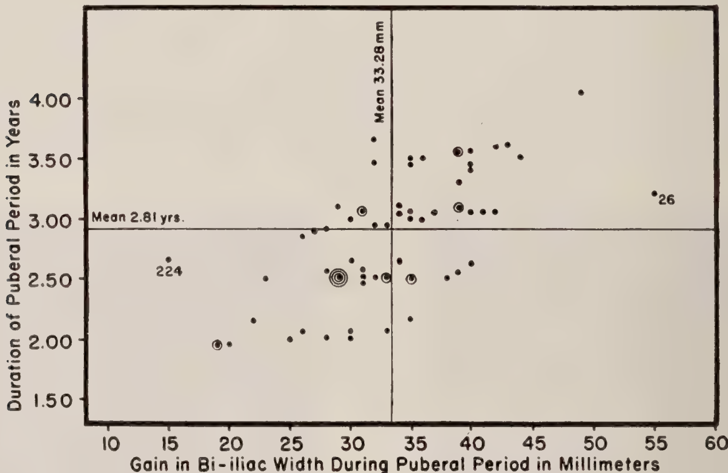


FIGURE 106. Relation of puberal gain in hip width to the duration of the puberal growth period for height. Coefficient of correlation .640, P.E. ± .049.

TIMING RELATION BETWEEN APEX GROWTH FOR HIP WIDTH AND FOR HEIGHT [10]

In 54 of the 67 cases (80.6 per cent) the maximum velocity for growth in bi-iliac width occurred within the puberal growth period for height; in 10 cases it occurred prior to this period; in 3 cases it occurred after this period.[11]

The cases were almost evenly divided between those having apex of bi-iliac growth prior to, synchronous with, or following the apex for height growth. In 24 cases (35.8 per cent) the apex for hip width coincided with the apex for height. In 21 cases (31.3 per cent) the apex for hip width preceded the apex for height; in 22 cases (32.8 per cent) it followed the height apex.

The extremes of asynchrony for this sample are represented by one case in which the apex velocity for hip width occurred 4.25 years before the apex velocity for height, and by one case in which it occurred 2.60 years after the height apex. The tendency toward coincidence is indicated by the

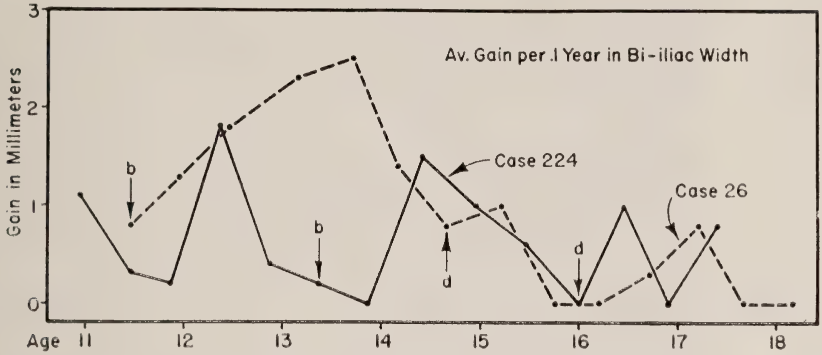
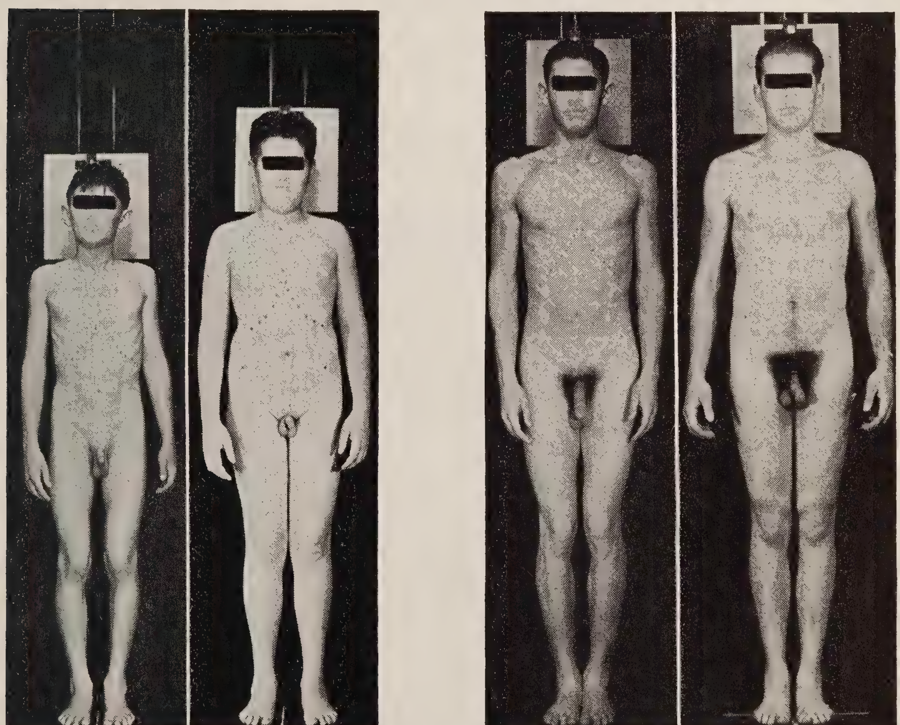


FIGURE 107a. Growth curves of two boys (Cases 26 and 224) who gained different amounts in hip width during the puberal period but had about the same measurements during the postpuberal period (d + 3). Case 26 gained 55 millimeters while Case 224 gained 15 millimeters. Case 224 made his apex growth before the onset of the puberal period. These cases can be seen in relation to the group in Figure 106.



	Case 26	Case 224	Case 26	Case 224
C.A.	11.4	13.3	16.0	17.2

FIGURE 107b. Photographs of the two boys at onset of the puberal growth period and during the postpuberal period whose curves are presented in Figure 107a.

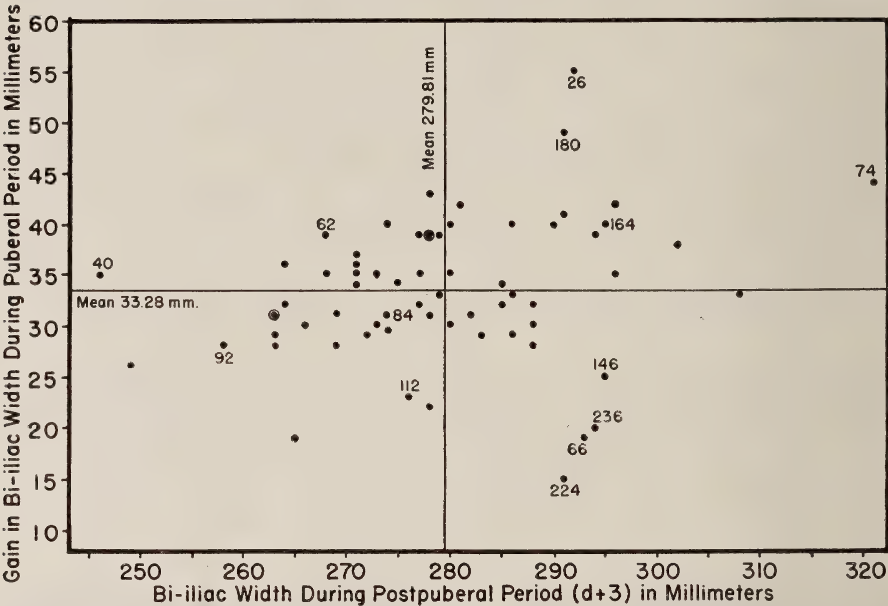


FIGURE 108. Relation of puberal gain in hip width to hip-width measurements during the postpuberal period (d + 3). Coefficient of correlation .254, P.E. ± .078. Cases 66, 224, and 236 were late developers with short duration of the puberal period. Their major gains were made before puberal onset. (See Figures 107a and b.) Cases 112 and 164 are described in Figures 109a and b.

finding that in 35 cases (52.24 per cent) the apex for hip width occurred within six months of the apex for height.

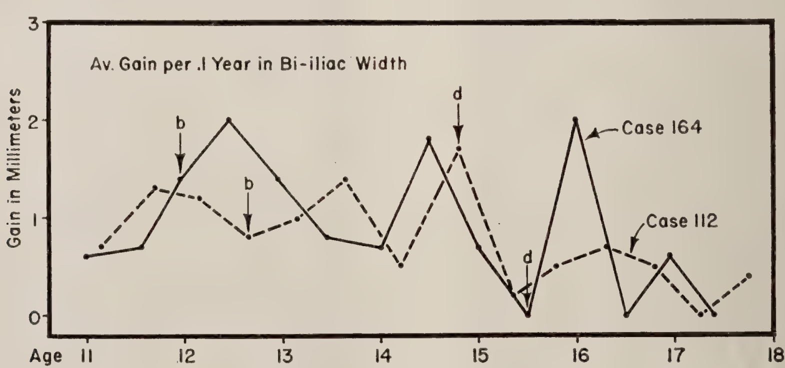
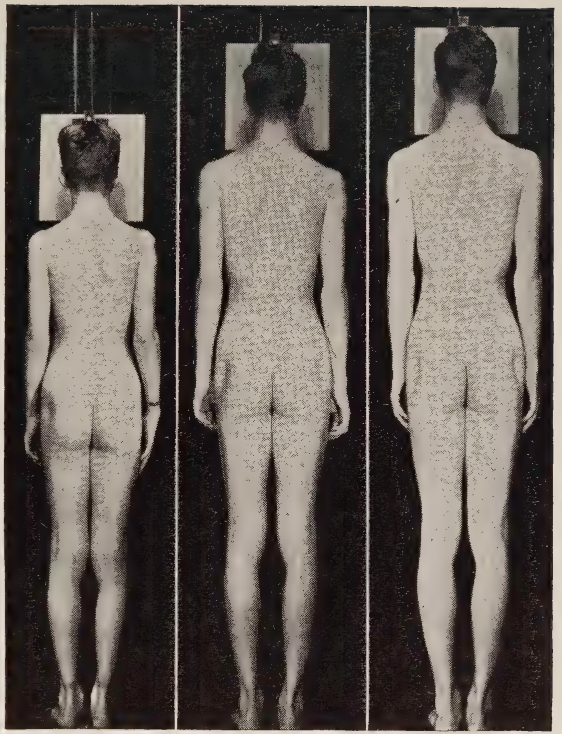


FIGURE 109a. Growth curves of two boys with contrasting growth in hip width. Case 112, a boy of medium hip width, made relatively small gains; Case 164, a broad-hipped boy, made relatively large gains.

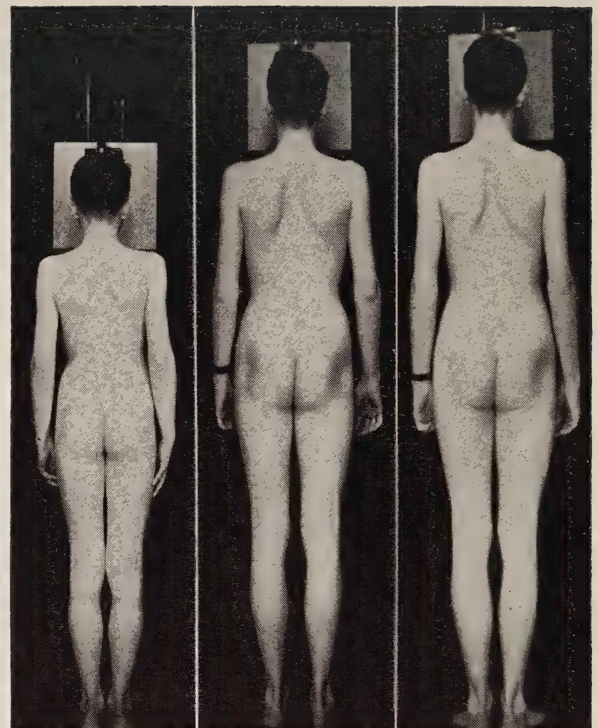
The timing relations between maximum growth velocities for these two body measurements are summarized in Table 39. Specimen individual



Case 112

C.A. 12.6 — 14.8 — 16.0

Puberal onset — Puberal end — Postpuberal



Case 164

C.A. 11.9 — 15.5 — 16.7

Puberal onset — Puberal end — Postpuberal

FIGURE 109b. Photographs of the two boys (Cases 112 and 164) whose growth curves for hip width are shown in Figure 109a.

curves illustrating the variations in timing relationship are shown in Figures 110a, b, and c.

Table 39 TIMING RELATIONS OF BI-ILIAC GROWTH APEX TO HEIGHT GROWTH APEX AND TO THE PUBERAL PERIOD

Relation of Bi-iliac Apex	*Number of Cases*	*Per Cent of 67 Cases*	*Years Difference* Average	Range
Synchronous with height apex	24	35.82		
Preceding height apex	21	31.34	1.85	.25–4.25
Preceding puberal onset	10	14.92	2.54	1.45–4.25
Preceding height apex but within puberal growth period	11	16.42	1.21	.25–2.05
Following height apex	22	32.83	.96	.50–2.60
Following end puberal period	3	4.48	2.02	1.50–2.60
Following height apex but within puberal growth period	19	28.36	.79	.50–2.00
Within ±.5 year of height apex	35	52.24		
Within puberal period for height	54	80.60		

THE CONFIGURATION OF THE GROWTH PROFILES FOR HIP WIDTH

Making allowance for the difference in magnitude, the growth velocity profiles for hip width show a slight configuration resemblance to those for stem length. There is a noticeable tendency toward consistent acceleration or consistent deceleration of growth velocity over a period of a year or more, so that the profiles are made up of a series of broad-based pyramids. The tall spires of rapid rise and fall in rate of growth, which are characteristic for shoulder width, occur much less frequently in the hip-width profiles.

From a systematic analysis of the frequency of major peaks and major dips [12] we found the mean frequency for our sample of hip-width profiles to be 2.85 major peaks; the range was from 1 to 5. In 6 cases the puberal apex was the only major peak; 16 cases showed two peaks; 30 cases showed three peaks; 14 cases, four peaks; 1 case, five peaks.

The range of frequency for major dips in our hip-width profiles was from 0 to 4 with a mean frequency of .81. In 31 profiles (46.27 per cent) no major dip occurred; in 22 (32.85 per cent), one major dip; in 13, two major dips; in 1 profile there were four such dips.

Thus the most common pattern showed three major peaks and no major dip. Examples of this will be found in Figure 105a (Case 84) and Figure 109a (Case 112). The two profiles in Figure 107a show contrasting infrequent patterns: Case 26 with one major peak and no major dip, Case 224 with four major peaks and four major dips.

Table 40 COMPARISON OF FREQUENCY OF MAJOR FLUCTUATIONS IN ADOLESCENT GROWTH PROFILES FOR HEIGHT, STEM LENGTH, LEG LENGTH, SHOULDER WIDTH, AND HIP WIDTH—67 BOYS

	Major Peaks						*Major Dips*						
Skeletal Growth	*Average per Case*	Distribution—Per Cent of Cases 1	2	3	4	5	*Average per Case*	Distribution—Per Cent of Cases 0	1	2	3	4	5
Height	1.61	46.27	46.27	7.46	0	0		98.51	1.49	0	0	0	0
Stem length	1.94	31.34	46.27	19.40	2.98	0		86.57	13.43	0	0	0	0
Leg length	2.57	7.46	53.73	32.83	5.97	0		91.04	8.95	0	0	0	0
Shoulder width	3.54	1.49	7.46	43.28	37.31	10.45	1.45	20.89	35.82	23.88	16.42	2.98	0
Hip width	2.85	8.95	23.88	44.78	20.89	1.49	.81	46.27	32.83	19.40	0	1.49	0

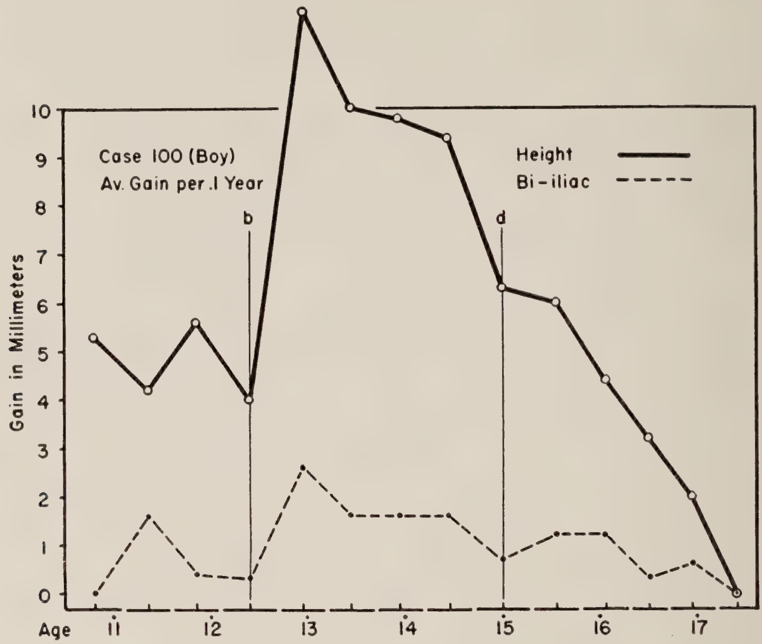


FIGURE 110a. Growth curves of a boy (Case 100) where apex of bi-iliac growth and apex of height growth are synchronous. Twenty-four cases (35.82 per cent) had similar timing.

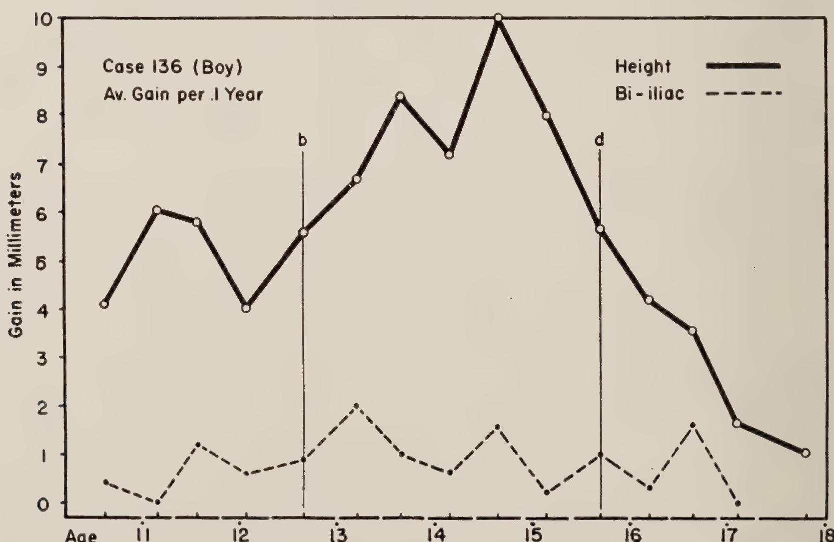


FIGURE 110b. Growth curves of a boy (Case 136) where apex of bi-iliac growth precedes apex for height growth. Twenty-one cases (31.34 per cent) had similar timing.

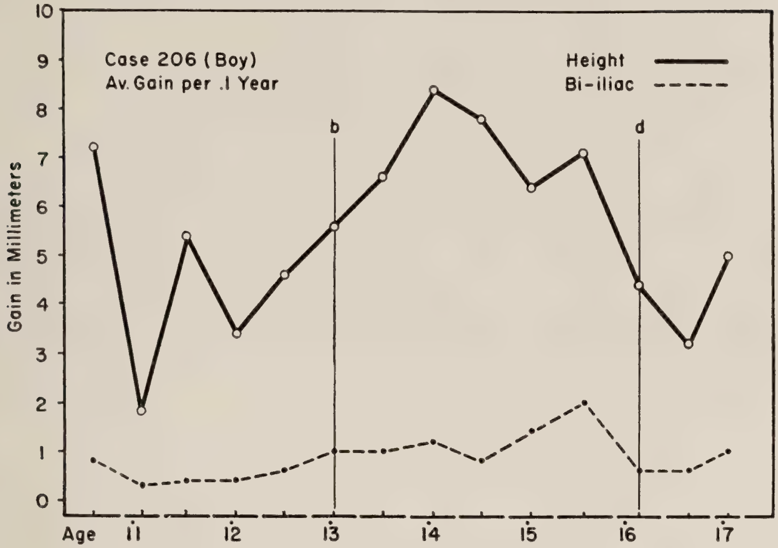


FIGURE 110c. Growth curves of a boy (Case 206) where apex of bi-iliac growth follows apex for height growth. Twenty-two cases (32.83 per cent) had similar timing.

In Table 40 a summary of the profile-configuration analysis of peaks and dips for the five skeletal measures of length and breadth is given. These data emphasize two characteristics previously mentioned; namely, the wide variation among individuals in any one measure and the significant differences between the contours of the five curves. The slight general resemblance of profile configuration between the curves for stem length and hip width arises from similarity of gradients in spite of the difference in frequency of major fluctuations.

Section C CHANGES IN RATIO OF SHOULDER WIDTH TO HIP WIDTH

The changes which take place in the relative width of shoulders and hips are important to boys who live in a culture where broad shoulders and narrow hips are considered important masculine attributes. We have analyzed these changes through a study of the biacromial/bi-iliac ratio.[13]

SHOULDER/HIP WIDTH RATIO AT DEVELOPMENTAL POINTS

The distributions of the 67 boys according to this ratio at the four developmental points are shown in Figures 111a, b, c, and d. The statistical analysis is given in Table 41.[14] The differences between the biacromial/bi-iliac ratios of the boys at the four successive developmental points were statistically significant except between b — 3 and b where the critical ratio

Shoulder/hip width ratio	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.50	1.52
						294												
						224		220	216									
					250	168	112	176	190		60	236						
					150	146	80	86	106	304	218	184						
					36	230	292	52	84	206	180	154						
					244	212	82	104	78	96	92	40						
					134	136	74	100	44	242	64	26	234					
					108	120	50	58	144	34	62	110	116					
	88		18	164	66	68	26	54	130	8	30	10	166			32		72

FIGURE 111a. Distribution of 67 boys according to shoulder/hip width ratio during the prepuberal period (b — 3): mean, 1.34; standard deviation, .061; median, 1.34; Q_1, 1.29; Q_3, 1.39.

Shoulder/hip width ratio	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44
								190	106				
						68	304	34	86	206			
						44	216	32	84	184	242		
						24	150	220	230	168	234		
					66	294	92	212	218	236	72		
			244		164	292	120	130	176	180	64		
			88	112	146	104	100	110	154	80	62		
		82	250	224	136	74	54	40	144	26	166	116	
	36	78	134	108	58	52	50	30	8	18	96	60	10

FIGURE 111b. Distribution of 67 boys according to shoulder/hip width ratio at onset of the puberal growth period for height: mean, 1.34; standard deviation, .055; median, 1.35; Q_1, 1.30; Q_3, 1.38.

Shoulder/hip width ratio	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.50	1.52
							212									
							112									
							110									
							74									
							52	304		236						
						100	50	104	154	144						
						292	176	44	92	206						
						224	130	24	80	184						
				68		146	106	220	32	180	60	242				
			88	58	294	136	40	218	8	168	216	18				
		36	82	108	250	120	34	90	230	116	84	150	64			
	244	134	66	78	164	54	26	30	96	86	72	62	234	166		10

FIGURE 111c. Distribution of 67 boys according to shoulder/hip width ratio at end of the puberal growth period for height: mean, 1.36; standard deviation, .060; median, 1.36; Q_1, 1.33; Q_3, 1.41.

							120									
							100	224	184	304						
					244		74	218	180	206						
					146		68	92	168	220						
					292		66	230	116	216						
					250	212	30	190	96	110	144					
					108	176	24	104	84	86	32		242			
					78	52	8	80	64	72	154		234			
			54		58	164	112	34	236	60	150		62			
	134	88	294	136	36	50	82	26	106	44	40		18		166	10
Shoulder/hip width ratio	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.50	1.52	1.54

FIGURE 111d. Distribution of 66 boys according to shoulder/hip width ratio during the postpuberal period (d + 3): mean, 1.39; standard deviation, .058; median, 1.39; Q_1, 1.35; Q_3, 1.43.

Table 41 RATIO OF SHOULDER WIDTH TO HIP WIDTH

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3
Prepuberal (b − 3)	1.19–1.52*	1.34	.061	1.34	1.29	1.39
Onset of puberal period (b)	1.32–1.44	1.34	.055	1.35	1.30	1.38
End of puberal period (d)	1.23–1.52	1.36	.060	1.36	1.33	1.41
Postpuberal (d + 3)	1.25–1.54	1.39	.058	1.39	1.35	1.43

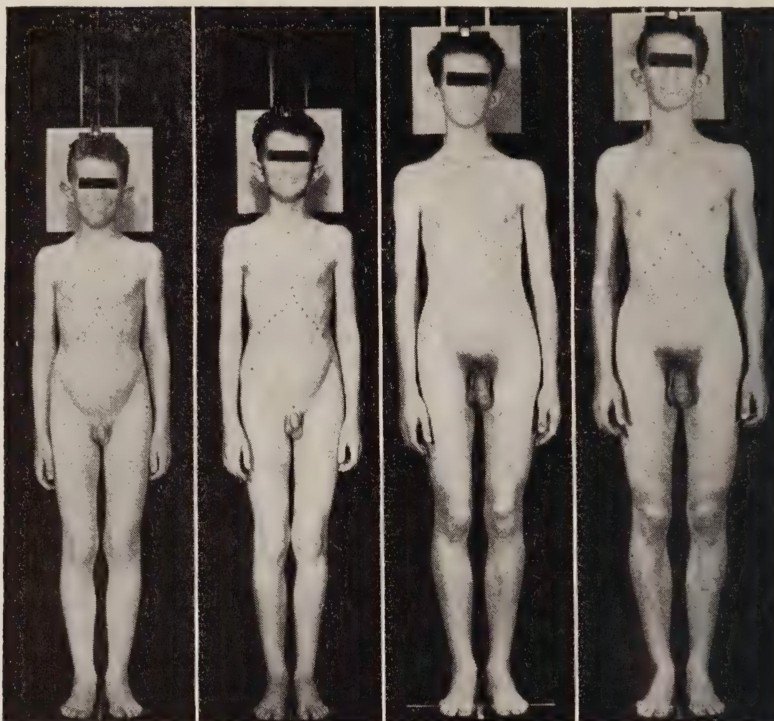
* The upper end of the range was Case 72 whose measurements were taken at b − 2.

was .66, indicating that these differences would occur by chance 254 times in a thousand. (See Appendix X.)

There were two boys who were consistently among the lowest ten per cent in each distribution (Cases 88 and 134). Two additional boys (Cases 36 and 108) were consistently among the lowest thirteen per cent. These were boys with relatively narrow shoulders and wide hips. Cases 36 and 88 had high subcutaneous tissue ratings and other sex-inappropriate characteristics.[15, 16] Figure 112 presents photographs of Cases 88 and 134.[17]

At the other end of the distribution there were two boys who consistently kept their positions among the highest ten per cent in shoulder/hip width ratio (Cases 166 and 234). There were two others who were among the ten per cent with broad shoulders and narrow hips at each developmental point except the prepuberal (Cases 10 and 242).[18] Figure 113 shows photographs of Case 242.

The consistency of the position of individual boys in the group at the four developmental points was relatively high. Table 42 gives the correlations between the ratios at various points.



Case 134

C.A. 12.1	13.3	15.5	16.8
Prepuberal	Puberal onset	Puberal end	Postpuberal

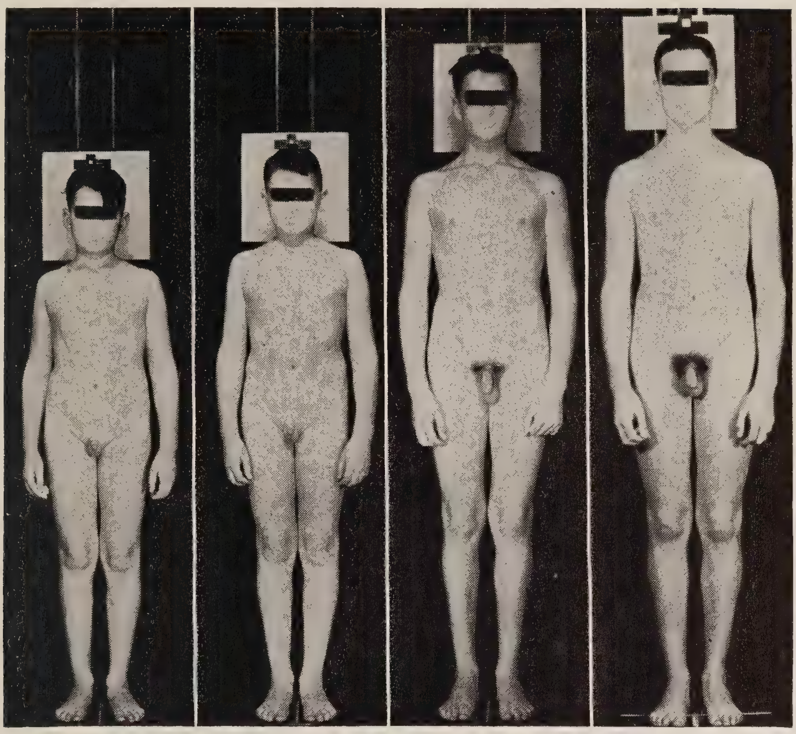
FIGURE 112.

Table 42 CORRELATIONS OF SHOULDER/HIP WIDTH RATIO AT DEVELOPMENTAL POINTS

	No. Cases	*r.*	*P.E.*
Prepuberal and puberal onset	67 62*	.658 .801	.047 .040
Puberal onset and end	67	.853	.022
Puberal end and postpuberal	66	.837	.025
Prepuberal and postpuberal	66	.581	.055

* Omitting five atypical cases.

There was a correlation between the ratios at the onset and end of the puberal period of .853 and between the end of the puberal period and the postpuberal point of .837. Between prepuberal point (b — 3) and the

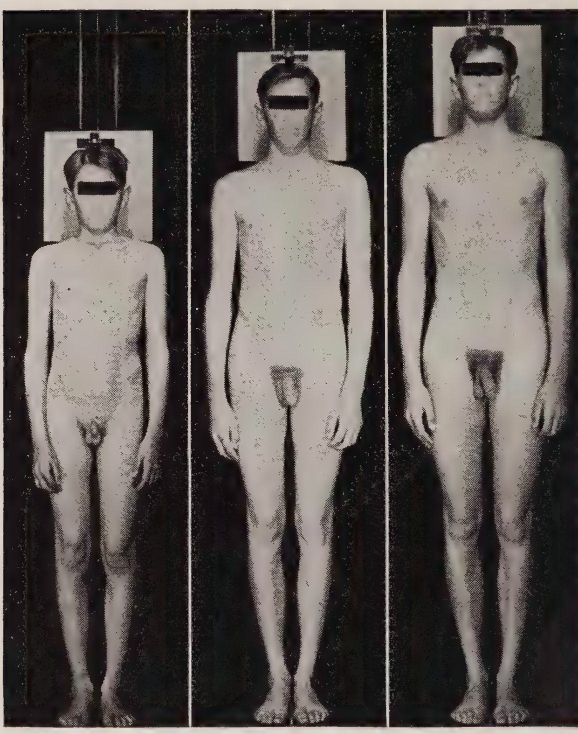


Case 88

C.A. 10.9	12.0	14.5	15.8
Prepuberal	Puberal onset	Puberal end	Postpuberal

FIGURE 112. Photographs of two boys who consistently had relatively narrow shoulders and wide hips. Case 88 had other sex-inappropriate characteristics. According to Sheldon's ratings of body types, Case 88 showed no dominant component at seventeen years, while Case 134 showed ectomorphic dominance.

onset of the puberal period there was less consistency in the position of individuals in the group (r. .658). Cases 18 and 168 made unusual gains, owing in part to the fact that both had the apex of biacromial growth just before the puberal onset. Cases 32, 72, and 78 made unusual losses; these three had high growth in hip width just before the onset. If these five cases are omitted from the sample, the correlation increases to .801, P.E. $\pm$.040. (See scatter diagram in Figure 114.) The lowest correlation, .581, was between the ratio at the prepuberal (b — 3) and postpuberal (d + 3) points. (See scatter diagram in Figure 115.) Cases 18 and 150 stand out because of their relatively unusual gains in shoulder breadth. Case 18 gained below the mean in bi-iliac but among the top fifteen per cent in shoulder width. Case 150 made an average increase in hip width but the



Case 242

C.A. 11.9	14.8	15.5
Puberal onset	Puberal end	Postpuberal

FIGURE 113. Photographs of Case 242 who had relatively broad shoulders and narrow hips at the three developmental points. According to Sheldon's rating of body types, he showed no dominant component at seventeen years. This boy was a good example of adolescent development without any deviations from an acceptable somatic pattern. There was neither noticeable precocity nor retardation; there was no early adolescent fat period; there was no time during adolescence when the pattern of change suggested even slight deviation from cultural ideals of sex-appropriate growth.

greatest gain of any boy in shoulder width. Both of these boys changed from the lower to the upper quartile in shoulder/hip width ratio during adolescence, while Cases 32 and 72 made less dramatic changes in the opposite direction. Figure 116 shows the developmental curves of three boys (Cases 88, 190, and 234) who kept a relatively consistent relationship to the group in shoulder/hip width ratio, while Figures 117a and b show curves and photographs of boys who made rather dramatic changes (Cases 18 and 32).[19]

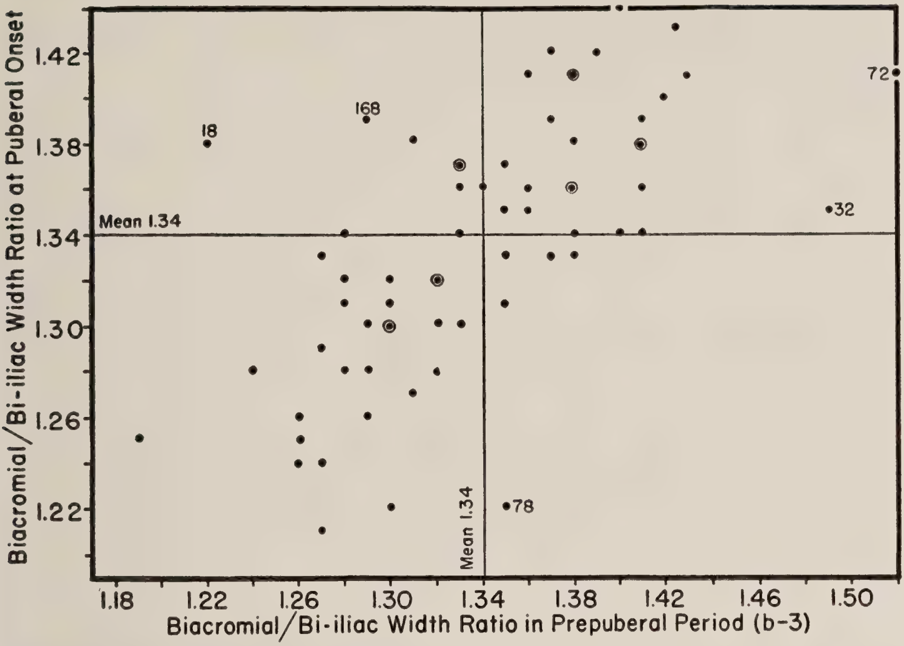


FIGURE 114. Relation of shoulder/hip width ratio at b — 3 in the prepuberal period and at the onset of the puberal growth period for height. Coefficient of correlation .658, P.E. ±.047. Cases 18 and 168 had shoulder-width apex just before the puberal onset. Cases 32, 72, and 78 had high hip-width growth just before the puberal onset, with the major growth in shoulder width coming late in the puberal or in the postpuberal period. With few exceptions the boys kept a relatively consistent relation to the group in shoulder/hip width ratio from the puberal onset to late adolescence. This probably means that during this period of adolescent growth there is a strong tendency toward parallel growth in these two width measurements.

THE CURVE OF SHOULDER/HIP WIDTH RATIO

The form of the growth curve for the ratio of shoulder to hip width is not so uniform as the corresponding curve for the ratio of stem length to height.[20] The lowest ratio occurred with almost equal frequency during the prepuberal period, at the puberal onset, or during the puberal period. (See Table 43.) The location of the highest ratio, however, was much more consistent, 79.10 per cent occurring during the postpuberal period. (See Table 44.) Developmental curves of shoulder/hip width ratio which illustrate varying locations of the lowest and highest ratio are shown in Figures 118 and 119.

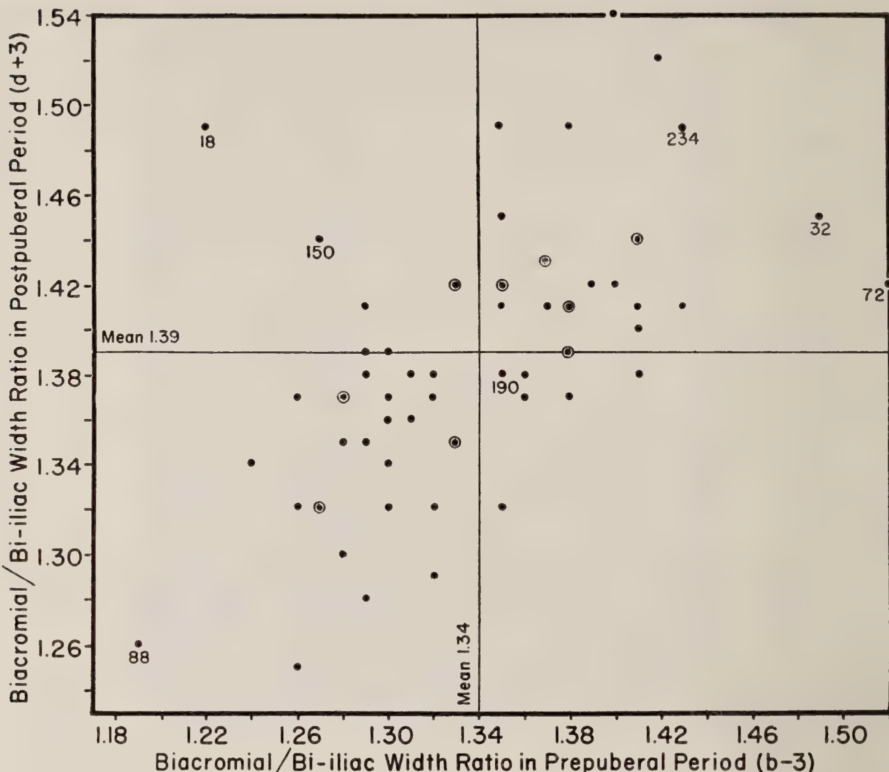


FIGURE 115. Relation between shoulder/hip width ratio during the prepuberal period (b — 3) and during the postpuberal period (d + 3). Coefficient of correlation .581, P.E. ±0.055. Cases 18 and 150 made dramatic increases in shoulder/hip width ratio, while Cases 32 and 72 made large losses. Growth curves for Cases 88, 190, and 234 are described in Figure 116, for Cases 18 and 32 in Figure 117.

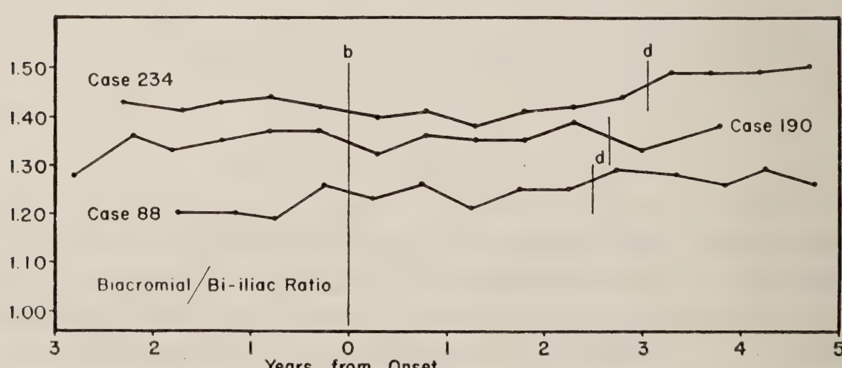


FIGURE 116. Curves of biacromial/bi-iliac ratio of three boys illustrating cases which kept a consistent relationship with the group at the four developmental points. Case 88 was consistently in the lowest ten per cent; Case 190 was consistently near the mean; Case 234 was consistently in the upper ten per cent. According to Sheldon's somatotype ratings, Case 234 had mesomorphic dominance at seventeen years, while the other two boys showed no dominant component.

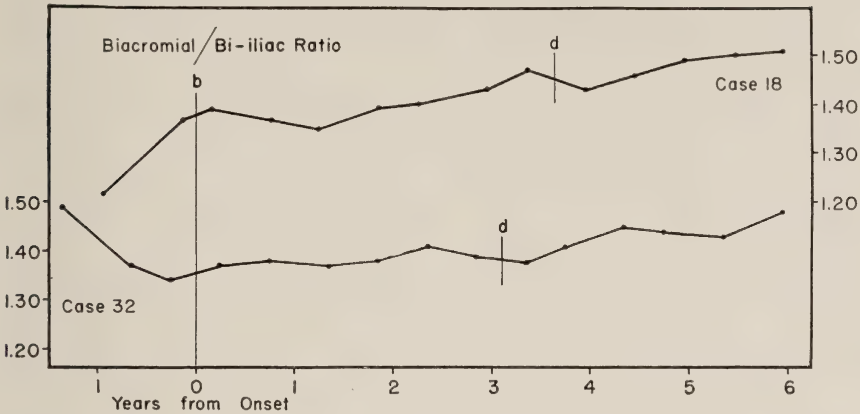


FIGURE 117a. Curves of biacromial/bi-iliac ratio of two boys who changed in relative position to the group from prepuberal to postpuberal periods. At these two points Case 32 had about the same ratio, but his relative position in the group had been lowered from next to highest to eighth from highest. Case 18 moved from the first quartile during the prepuberal period to the fourth quartile during the postpuberal period. Case 18 had a relatively long puberal period (3.65 years). (See Figures 111a and d, pages 192 and 193.)

Case 18

C.A. 10.8 16.7

Prepuberal Postpuberal

FIGURE 117b. Photographs of Case 18 who made such dramatic changes in biacromial/bi-iliac ratio. (See curve in Figure 117a.) According to Sheldon's ratings of body types, Case 18 had mesomorphic dominance.

Table 43 TIMING OF THE LOWEST RATIO OF BIACROMIAL WIDTH TO BI-ILIAC WIDTH

	Number of Cases	*Per Cent of 67 Cases*
Preceding onset puberal period	25*	37.31
During puberal period	41†	61.19
At b	20‡	
Between b and c	8	
At c	4	
Between c and d	8	
At d	1	
Following puberal period	1	1.49

* Eighteen of these were at the first examination.
† Eight cases had two low points and two cases had three low points distributed as follows: four cases had a second low point before onset of puberal period; one case had two low points before the puberal onset; one case had a second low point after the end of the puberal period; three cases had two low points during the puberal period; one case had two low points during the puberal period and one at the end of the puberal period.
‡ Two of these were at the first examination.

Table 44 TIMING OF THE HIGHEST RATIO OF BIACROMIAL WIDTH TO BI-ILIAC WIDTH

	Number of Cases	*Per Cent of 66 Cases*
Preceding onset puberal period	8	11.94
During puberal period	5*	7.46
Following end of puberal period	53†	79.10

* Two of these were at d, the end of the puberal period.
† Thirty-four of these were at the last examination.

The varying locations of the lowest and highest points in the shoulder/hip width ratio curve make it difficult to analyze the general trends of the individual curves in relation to these points. In Table 45 are shown the changes in shoulder/hip width ratio at the four developmental points of the height growth curve (b — 3, b, d, and d + 3).

Changes in shoulder/hip width ratio from the prepuberal point (b — 3) to the puberal onset varied greatly among the 67 cases, with 47.8 per cent decreasing, 37.3 per cent increasing, and 14.9 per cent remaining the same. But from the beginning of the puberal period there was a strong tendency for the ratio to increase both during the puberal period (77.6 per cent) and after (71.2 per cent). There were 70 per cent of the cases that increased from the puberal onset to the puberal end and on to the post-puberal point (b to d to d + 3). In spite of fluctuations in many of the curves we can conclude in general that the accepted masculine build of

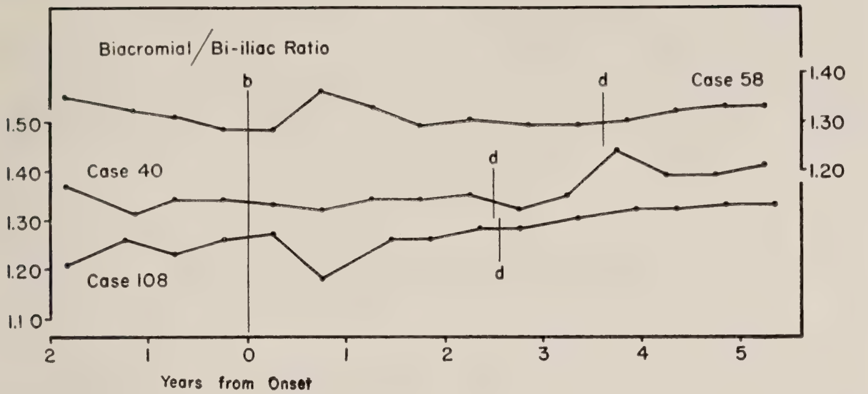


FIGURE 118. Curves of shoulder/hip width ratio illustrating locations of the lowest ratio before onset of the puberal period (Case 40); at onset of the puberal period (Case 58); and during the puberal period (Case 108). The lowest ratio for the 67 cases occurred with about equal frequency at these locations.

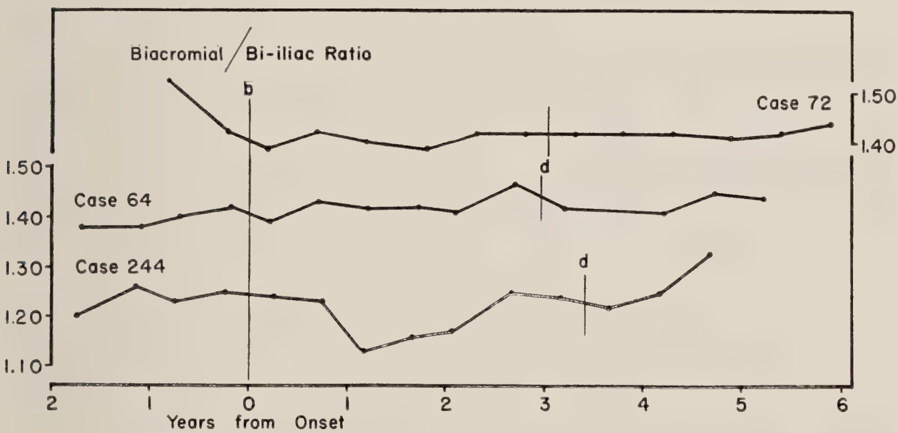


FIGURE 119. Curves of shoulder/hip width with ratio illustrating the location of the highest ratio before puberal onset (Case 72); during the puberal period (Case 64); and after the close of the puberal period (Case 244). The highest ratio occurred after the close of the puberal period in 79.10 per cent of the cases.

broad shoulders and narrow hips is partly a product of adolescent development for a large number of boys. Figures 120 and 121 show examples of curves illustrating typical and nontypical curves.

As will be seen in Table 45 there were ten cases (15.15 per cent) whose shoulder/hip width ratio was less at the postpuberal point than it had been at the prepuberal point. We endeavored to analyze what factors might have contributed to this unusual trend in their development. Table 46 summarizes this analysis. Three cases had an increase in ratio after d + 3 in

the postpuberal period. Three other cases were among the lowest ten per cent in puberal gain in shoulder breadth.[21] An additional case had high puberal gain in hip width.[22] Of the three remaining cases there were two where the data were inadequate for complete analysis.[23] One case seemed to defy analysis.[24]

Table 45 CHANGES IN BIACROMIAL/BI-ILIAC RATIO

	Decrease		*Same*		*Increase*	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
From prepuberal to onset puberal (b − 3 to b)	32	47.76	10	14.92	25	37.31
From onset to end of puberal (b to d)	8	11.94	7	10.45	52	77.61
From end of puberal to post-puberal (d to d + 3)*	11	16.67	8	12.12	47	71.21
From prepuberal to post-puberal (b − 3 to d + 3)*	10	15.15	3	4.54	53	79.10
From puberal onset to puberal end to postpuberal (b to d to d + 3)*	19	28.36			47	70.15

* Based on 66 cases.

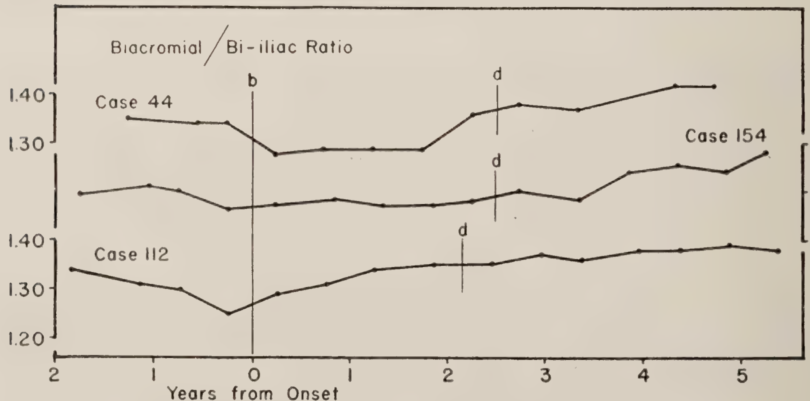


FIGURE 120. Illustrative curves (Cases 44, 112, and 154) of shoulder/hip width ratio which combine the more usual features of the changes in the curve; namely, decrease to the puberal onset, increase during the puberal period and later, with a general increase from the prepuberal to postpuberal period. According to Sheldon's ratings of body types, these boys had low endomorphic components but no dominant component.

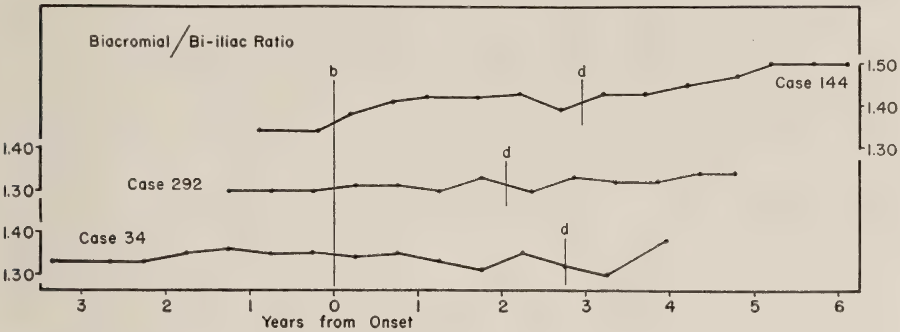


FIGURE 121. The curve of shoulder/hip width ratio of Case 144 illustrates those curves which show a general tendency to increase during the prepuberal, puberal, and postpuberal periods. Curve of Case 292 illustrates the tendency to keep a somewhat even ratio throughout. Case 34 shows a similar tendency but is the only case with the lowest ratio during the postpuberal period. According to Sheldon's somatotype ratings, these boys all show low endomorphic components; Cases 34 and 292 had mesomorphic dominance; Case 144, ectomorphic dominance.

Table 46 POSSIBLE CAUSES OF DECREASE IN BIACROMIAL/BI-ILIAC RATIO FROM b — 3 TO d + 3

Case	*Ratio Increased after d + 3*	*Puberal Biacromial Gain—Low*	*Puberal Bi-iliac Gain—High*	*Inadequate Data* Pre-puberal	Post-puberal
26	x		x	x	
30					x
32					
54		x			
72				x	
78	x				
116	x				
134		x			
236		x			
294			x	x	
Total 10	3	3	2	4	

RELATION OF SHOULDER/HIP WIDTH RATIO TO SOMATOTYPES

Ratings of body types were made from the photographs by W. H. Sheldon.[25] These ratings are a combination of evaluations of three components designated as endomorphic, mesomorphic, and ectomorphic, each rated on a seven point scale. The ratings were made from photographs taken at approximately seventeen years of age. Table 47 shows the correlation of the ratings on each of these components with the shoulder/hip width ratio during the postpuberal period (d + 3).

Table 47 CORRELATION OF SHOULDER/HIP WIDTH RATIO WITH RATINGS ON COMPONENTS OF BODY TYPES

Components	*Shoulder/Hip Width Ratio d + 3*	
	r.	P.E.
Endomorphic	−.260	.077
Mesomorphic	+.370	.072
Ectomorphic	−.186	.080

There is a greater tendency for boys with high shoulder/hip width ratio to receive a high rating in mesomorphic component than in either of the other components. However, as has been pointed out in the examples given previously in this chapter, there are individuals who do not follow this tendency. Case 242 was a broad-shouldered narrow-hipped boy who was rated 3.5 (endomorphic), 4 (mesomorphic) and 4 (ectomorphic).[26] However, he was the only boy among the top twelve per cent in shoulder/hip width ratio who *did not* have mesomorphic dominance. Similarly, there was only one case in the lowest twelve per cent who *did* have mesomorphic dominance. Among the 66 boys there were 22 (33.33 per cent) who had mesomorphic dominance; of these only 3 cases were below the mean in shoulder/hip width ratio. It would seem fair to conclude, therefore, that for our sample of boys those who were of the big-boned, muscular body type were likely to have shoulders broad in relation to their hip width.

SUMMARY

Growth in width diameters during adolescence was studied through analysis of the seriatim measurements of biacromial width and bi-iliac width for 67 boys. In making this analysis the measurements of width achieved at each of the four developmental points for height were used as the primary data for determining the range of individual variation in these measures at successive stages of development. The timing of apex growth in shoulder width and hip width was studied in relation to these developmental points and in relation to apex growth for height. The absolute and percentage gain during the puberal period was analyzed, and also the trend of the biacromial/bi-iliac ratio during adolescence. An attempt was made to describe the configurational peculiarities of the growth profiles for each of the two width diameters.

For our sample biacromial width at Point b — 3 close to the onset of adolescence ranged from 273 millimeters to 363 millimeters (10.75 inches to 14.29 inches); bi-iliac width from 208 millimeters to 269 millimeters (8.18 inches to 10.59 inches). At Point d + 3, close to the end of the postpuberal period, biacromial width ranged from 355 millimeters to 445

millimeters (13.98 inches to 17.52 inches); bi-iliac width from 246 millimeters to 325 millimeters (9.69 inches to 12.80 inches).

The coefficients of variation for hip width were greater than those for shoulder width at all four developmental points. Both the width measurements were more variable than either height or stem length. Hip width and leg length variability showed the closest resemblance. Whereas the length measures showed consistently decreasing variability throughout adolescence, the width measures showed variability decreasing to the end of the puberal period and then increasing during the postpuberal period.

The greatest gain in shoulder width during the puberal period (b to d) was 80 millimeters (3.15 inches); in hip width 55 millimeters (2.17 inches). The least gain in the same period was shoulder width 25 millimeters (.95 inch), hip width 15 millimeters (.59 inch). The amounts which a boy gained in hip width and shoulder width were, in most cases, closely related to the duration of the puberal period. However, for a considerable number of our cases, differences in rate of growth played a significant part in determining the gain achieved.

There was a definite tendency for boys destined to have the broadest shoulders in later adolescence to make the largest puberal gains in shoulder width; and the same sequence was prevalent for hip width. However, there were some outstanding exceptions to these generalizations.

Apex growth in shoulder width occurred within the puberal period in 76.05 per cent of cases; the apex for hip width lay within that period in 80.6 per cent of cases. The apex for hip width preceded the apex for height in about one third of the cases, was synchronous with height in about one third, and followed in about one third. The apex for shoulder width occurred before the height apex in about three eighths of the cases, was synchronous in less than one eighth, and followed in about one half.

The tendency for hip-width growth to show a simple rhythmic relation to height growth was not so obvious as for stem length and leg length, but it could be seen in more than half of the profiles. For shoulder width such a relation was exceptional. Indeed, wide variability of rate and timing is characteristic for shoulder-width growth. This is true not only as regards the major features of the profile but also for the minor fluctuations. The six month alternations of acceleration and deceleration occur more consistently than in the profiles of any of the other skeletal measures.

As regards the biacromial/bi-iliac ratio, there was a general tendency for this to increase during adolescence, but the increase among the boys in our sample was usually small and gradual. There was no characteristic pattern of timing such as was found for the adolescent changes in stem length/height rates. The lowest biacromial/bi-iliac ratio sometimes oc-

curred in the prepuberal period, sometimes early in the puberal, sometimes late in the puberal period. The only feature with a definite timing relation was the highest biacromial/bi-iliac ratio which occurred during the post-puberal period in over 80 per cent of the cases. It is very probable that in some cases even this apex would have been superseded by changes during later adolescence which were beyond the range of our data collection.

FOOTNOTES FOR CHAPTER VII

[1] For a description of the technique of making these measurements, see Chapter III, pages 22, 23, 24.

[2] See pages 31, 32.

[3] For complete data upon which this section is based, see Appendix L.

[4] See growth chart in Figure 129b. page 236.

[5] See growth chart of Case 176 in Figure 98b, page 171 and Figure 125c, page 224.

[6] Complete data for the 67 boys upon which this discussion is based will be found in Appendix M.

[7] There were three boys who made their highest gain in biacromial width at two consecutive examinations; the age at the mid-point was taken as the apex age. The three cases were Cases 112, 234, and 242. There was one boy (Case 36) who made equal maximum gains at two examinations which were not contiguous, but both were within the puberal growth period for height. The apex nearest the height apex was arbitrarily taken. Note that Case 36 also had two apexes for leg length.

[8] For the definition of major peaks and major dips, see page 114 in Chapter V. Frequency table for all measurements studied is in Appendix H.

[9] The data upon which this section is based will be found in Appendix N.

[10] Complete data for the 67 cases upon which this analysis is based will be found in Appendix M.

[11] There was one boy (Case 294) who made his highest gain in bi-iliac width at two consecutive examinations; the age at the mid-point was taken as the apex age. There were four boys (Cases 40, 164, 190, and 304) who made equal maximum gains at two examinations and one boy (Case 236) at three examinations which were not contiguous. The apex nearest the height apex was arbitrarily taken.

[12] The definition of major peaks and major dips is given on page 114. A comparative frequency table for all skeletal measurements studied will be found in Appendix H.

[13] Biacromial width divided by bi-iliac width.

[14] Complete data for the 67 boys upon which this discussion is based will be found in Appendix N.

[15] See Chapter XV.

[16] According to Sheldon's ratings of somatotypes, Cases 36, 88, and 108 had no dominant component of body type when they were seventeen to eighteen years old. Case 134, on the other hand, had a rating which indicated ectomorphic dominance.

[17] See Figure 57b, page 103, for photographs of Case 36. See Figure 129a, page 235, for biacromial curve of Case 88. See Figure 53b, page 97, for photographs of Case 108.

[18] According to Sheldon's ratings on somatotypes, Cases 10, 166. and 234 had mesomorphic dominance at seventeen years, while Case 242 showed no dominant component. (See page 203.)

[19] According to Sheldon's ratings on somatotypes, Case 234 showed mesomorphic dominance, while Cases 88 and 190 showed no dominant component. Case 18 also showed mesomorphic dominance, while Case 32 showed ectomorphic dominance.

[20] See discussion, page 135.

[21] According to Sheldon's somatotype ratings, these three cases (54, 134, and 236) had ectomorphic dominance.

[22] According to Sheldon's somatotype ratings, Case 294 showed mesomorphic dominance.

[23] The prepuberal point was taken after $b - 3$ and the postpuberal point was taken before $d + 3$.

[24] See curve of this case (Case 32) in Figure 117a, page 199.

[25] For a discussion of the technique used see Sheldon, W. H.; Stevens, S. S.; and Tucker, W. B.: *The Varieties of Human Physique,* Harper & Brothers, New York, 1942, pp. xii, 347.

[26] Ratings were on a seven point scale in which 1 was low.

Chapter VIII TIMING RELATIONS AMONG PHENOMENA OF SKELETAL GROWTH DURING ADOLESCENCE

IT has been pointed out by Bean [1] and other investigators that the human body does not grow at a steady rate, nor do the several parts of the body grow at the same rate at the same time. The data collected for our sample make it possible to expand somewhat our knowledge about this phenomenon of alternating, or at least successive, growth impulses during adolescence.

In describing the growth of our sample in stem length, leg length, shoulder width, and hip width, we have included, for each, data concerning the timing relation of its growth velocity apex to the apex for height. In this chapter we will discuss the timing interrelations among the apexes for leg length, stem length, and height; among the apexes for shoulder width, hip width, and height; and, finally, we will summarize and discuss the apex-timing-relation patterns for all five measurements.

Table 48 TIMING RELATIONS OF LEG LENGTH GROWTH APEX TO STEM LENGTH GROWTH APEX AND THE PUBERAL PERIOD FOR HEIGHT

Relation of Leg Length Apex	*Number of Cases*	*Per Cent of 67 Cases*	*Years Difference* Average	*Years Difference* Range
Synchronous with stem length apex	5	7.46		
Preceding stem length apex	49	73.13	1.36	.25–5.00
Preceding puberal onset	9	13.43	3.19	1.90–5.00
Preceding stem length apex but within puberal period	40	59.70	.94	.25–3.05
Following stem length apex	13	19.40	.59	.25–1.45
Within ±.5 year of stem length apex	32	47.76		
Leg length apex and stem length apex within puberal period for height	58	86.57		

Section A TIMING RELATIONS IN GROWTH OF STEM LENGTH, LEG LENGTH, AND HEIGHT

TIMING RELATIONS BETWEEN STEM LENGTH AND LEG LENGTH GROWTH

Timing of growth apexes. A comparison of the timing of the apex of growth velocity of leg length and of stem length is shown in Table 48.

It will be noted that in only 5 cases (7.46 per cent) do these two apexes occur at the same time. While the apex for leg length precedes the apex for stem length in 49 cases (73 per cent) it follows stem length in only 13 cases (19 per cent). In almost half of the cases the two apexes occur within six months of each other. Individual growth velocity curves which illustrate these variations are shown in Figures 122a, b, c, d, e, and f.

Acceleration and deceleration of stem length and leg length growth. It is not only in timing of apex growth that the pattern for stem length varies from that for leg length. To demonstrate this an analysis of the acceleration-deceleration pattern of growth in stem length and growth in leg length during the puberal growth period for height (b to d) was made. For each case the total number of intervals between successive semiannual examinations was counted; the profiles were scanned to determine in how many of these intervals stem length growth and leg length growth accelerated together and in how many one accelerated while the other decelerated; the ratio of the number of intervals in which correspondence occurred to the total number of intervals during the puberal growth period was then expressed in terms of percentage correspondence. The summary for 67 cases is shown in Table 49.

Table 49 CORRESPONDENCE BETWEEN TIMING OF ACCELERATION-DECELERATION RHYTHM FOR STEM LENGTH GROWTH AND LEG LENGTH GROWTH DURING THE PUBERAL GROWTH PERIOD

Percentage Correspondence	*Number of Cases*	*Per Cent of Cases*
100	1	1.49
80–99	8	11.94
60–79	14	20.89
40–59	17	25.37
20–39	21	31.34
1–19	3	4.48
0	3	4.48

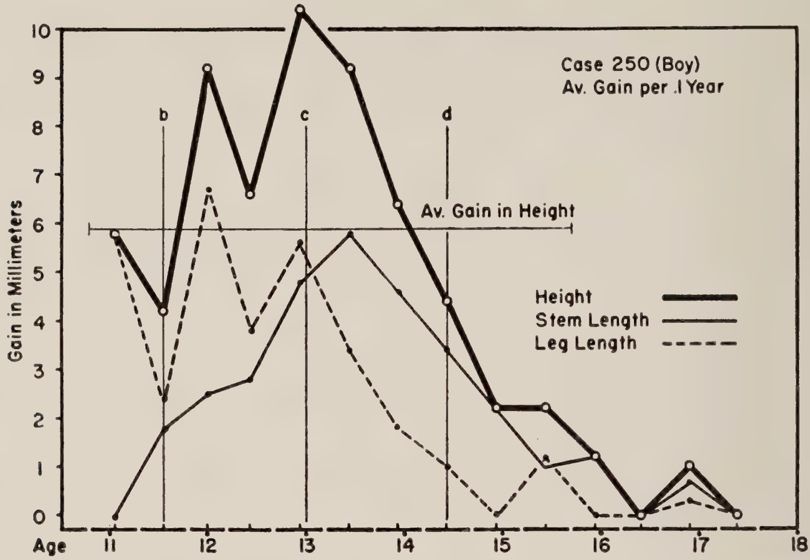


FIGURE 122a. Growth curves of boy (Case 250) illustrating 1.45 years priority of leg length apex to stem length apex. There were eleven cases (16.42 per cent) with leg length apex priority between 1.05 years and 1.6 years.

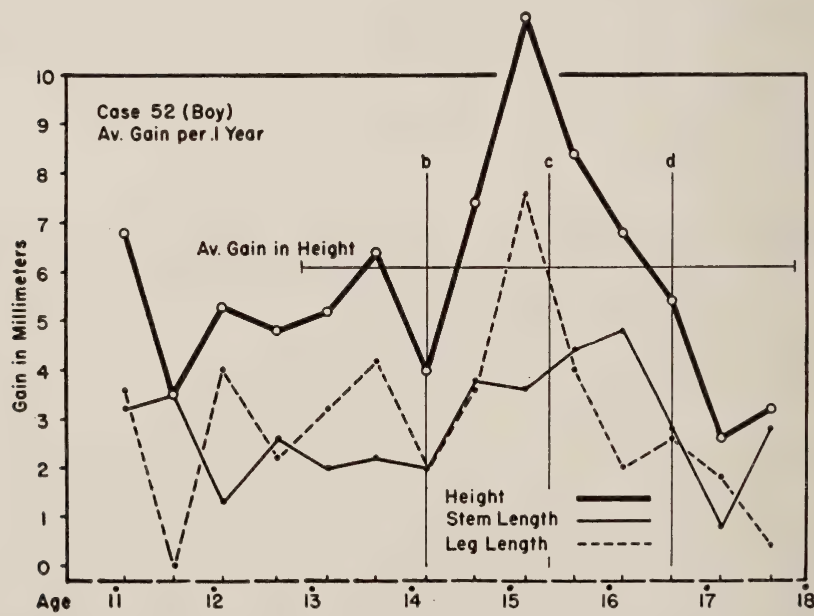


FIGURE 122b. Growth curves of boy (Case 52) illustrating 1.0 year priority of leg length to stem length apex. There were eleven cases (16.42 per cent) with leg length apex between .55 year and 1.00 year prior to stem length apex.

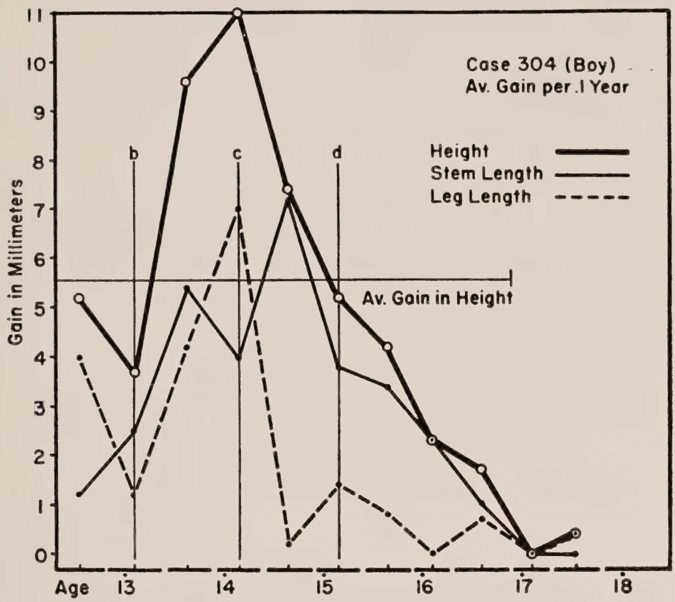


FIGURE 122c. Growth curves of boy (Case 304) illustrating .5 year priority of leg length apex to stem length apex. There were sixteen cases (23.88 per cent) with leg length priority of between .25 year and .5 year.

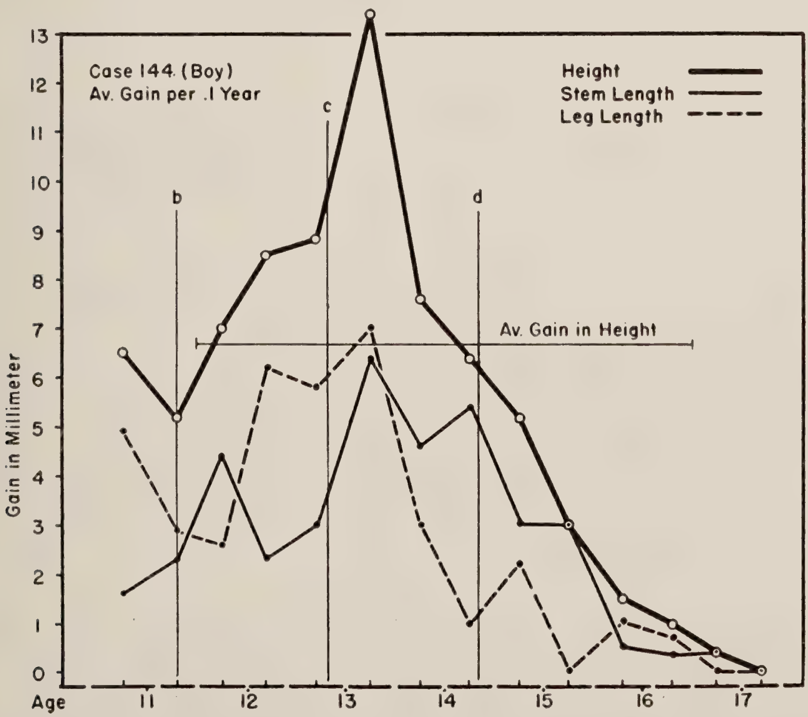


FIGURE 122d. Growth curves of boy (Case 144) illustrating simultaneous timing of leg length apex and stem length apex. There were five such cases (7.46 per cent).

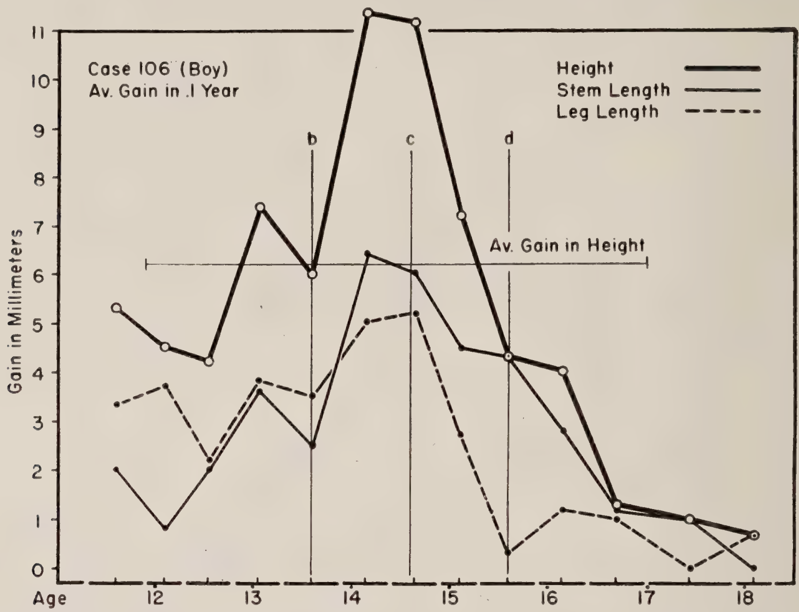


FIGURE 122e. Growth curves of boy (Case 106) illustrating leg length apex .50 year after stem length apex. There were eleven cases (16.42 per cent) where apex leg length followed apex stem length by from .25 years to .50 year.

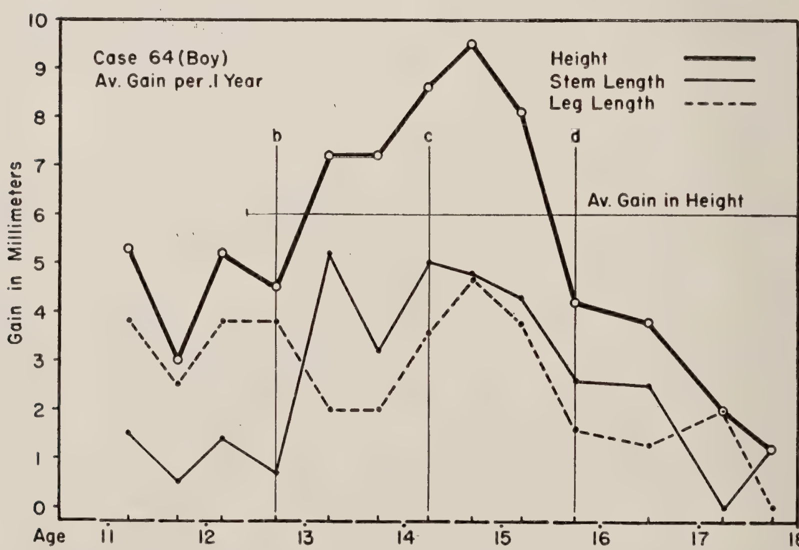


FIGURE 122f. Growth curves of boy (Case 64) illustrating leg length apex 1.45 years after stem length apex. This was the largest interval among the 67 cases. There were only two cases (2.98 per cent) where apex leg length followed apex stem length by more than a half year.

There was a wide variation in the amount of correspondence of the stem length and leg length curves during the puberal period from one case with complete correspondence to three cases with no correspondence. Most of the cases, however, had between 20 and 80 percentage correspondence. Over half (56.72 per cent) had correspondence in the two curves in from twenty to sixty per cent of the time.

Analysis of the time when correspondence between the two curves was most likely to occur yielded interesting comparisons. During the first half year of the puberal period, growth in both stem length and leg length accelerated in 45 of the 67 cases (67.16 per cent); during the half year immediately preceding the apex growth in height, stem length and leg length growth accelerated together in 33 cases (49.25 per cent); during the half year immediately following the height apex, stem length and leg length growth decelerated together in 29 cases (43.28 per cent); during the last half year of the puberal period, they decelerated together in 32 cases (47.76 per cent).

Specimens of varying patterns of correspondence in acceleration and deceleration of growth in stem length and in leg length are shown in Figures 123a, b, c, and d.

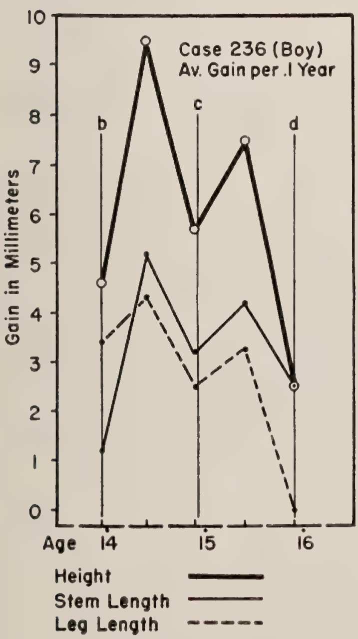


FIGURE 123a. Growth curves of Case 236 illustrating complete correspondence in acceleration and deceleration of the velocity curves for stem length and leg length during the puberal growth period of height. This was the only case of complete correspondence.

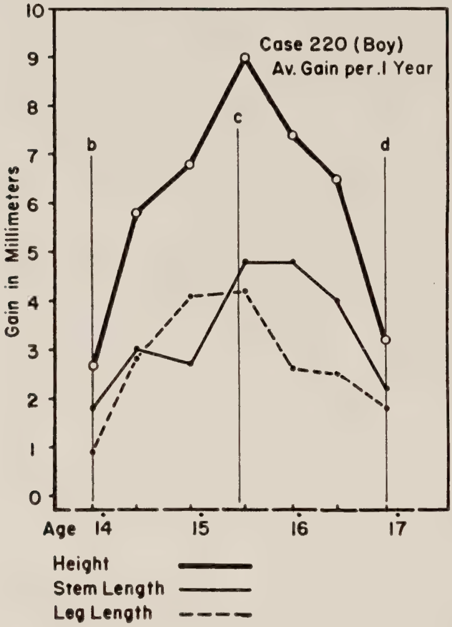


FIGURE 123b. Growth curves of Case 220 illustrating correspondence in acceleration and deceleration of the velocity curves for stem length and leg length during two thirds of the puberal growth period. There were 34 cases (50.75 per cent) which showed correspondence in the first half year of the puberal growth period; there were 33 cases (49.25 per cent) which showed correspondence in acceleration in the half year immediately preceding the apex of height; and there were 32 cases (47.76 per cent) which showed correspondence in deceleration during the last half year of the puberal period.

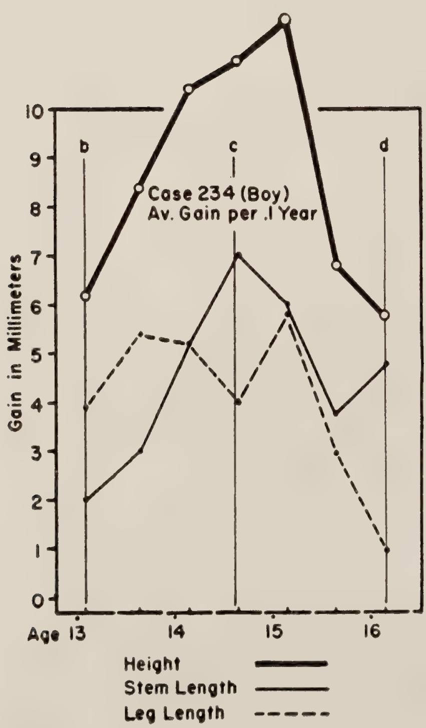


FIGURE 123c. Growth curves of Case 234 illustrating correspondence in acceleration and deceleration of the velocity curves for stem length and leg length during one third of the puberal growth period. There were 33 cases (49.25 per cent) with correspondence less than 50 per cent of the time. This case also illustrates acceleration correspondence in the first half year of the puberal period and correspondence in deceleration immediately after the height apex.

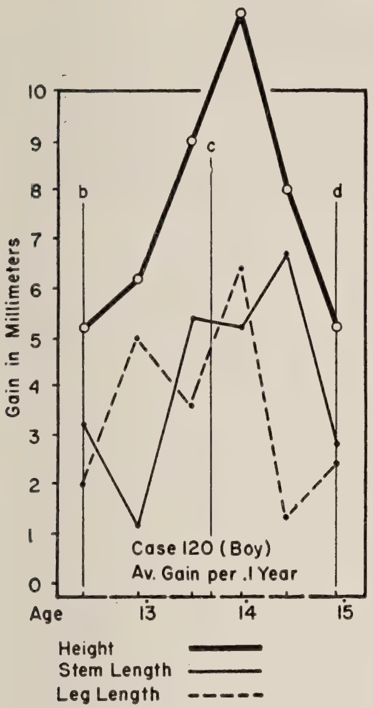


FIGURE 123d. Growth curves of Case 120 illustrating complete lack of correspondence in acceleration and deceleration of the velocity curves for stem length and leg length during the puberal growth period for height. There were three such cases (4.48 per cent) with no correspondence.

TIMING INTERRELATIONS OF APEX GROWTH AMONG STEM LENGTH, LEG LENGTH, AND HEIGHT

In Table 50 are shown the variations among 67 boys in relative timing of apex velocity growth in height, leg length, and stem length during the adolescent period.

Summarizing these distributions we find that:

In 45 cases (67.16 per cent) the stem length apex occurred within + or —.5 year of the height apex.

In 49 cases (73.13 per cent) the leg length apex occurred within + or —.5 year of the height apex.

In 32 cases (47.76 per cent) the leg length apex occurred within + or —.5 year of the stem length apex.

In 30 cases (44.78 per cent) the leg length apex and the stem length apex occurred within + or —.5 year of the height apex.

We may conclude, therefore, that the tendency for maximum growth to occur during the same year was strongest between height and leg length, almost as strong between height and stem length, and definite but not strong between leg length and stem length.

Table 50 RELATIVE TIMING OF STEM LENGTH APEX, LEG LENGTH APEX, AND HEIGHT APEX—67 BOYS

Differences in Years	*Stem Length to Height Cases*		*Leg Length to Height Cases*		*Leg Length to Stem Length Cases*	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
−5.00					1	1.49
−4.50					1	1.49
−4.00					0	.00
−3.50			3	4.48	3	4.48
−3.00			2	2.98	2	2.98
−2.50			1	1.49	3	4.48
−2.00			2	2.98	3	4.48
−1.50	1	1.49	3	4.48	8	11.94
−1.00	0	.00	6	8.95	12	17.90
−.50	9	13.43	6	8.95	16	23.88
0	23	34.33	38	56.72	5	7.46
+.50	13	19.40	5	7.46	11	16.42
+1.00	9	13.43	1	1.49	1	1.49
+1.50	6	8.95			1	1.49
+2.00	5	7.46				
+2.50	0	.00				
+3.00	0	.00				
+3.50	1	1.49				

Tables 51a and b give a further analysis of these interrelationships within individual cases. It will be seen that in the 23 cases where apex stem length was synchronous with apex height, 5 also had leg length synchronous, 14 had leg length prior, and 4 had leg length following the height apex.

On the other hand, of the total 38 cases where leg length was synchronous with height apex, 8 had stem length prior and 25 had stem length following the height apex.

Table 51b gives this same analysis by percentage of cases. The highest percentage was for cases with leg length synchronous and stem length later

(37.31 per cent); the next highest was for cases with stem length synchronous and leg length prior (20.89 per cent).

These tables emphasize the timing variation in patterns of growth velocity for these dimensions but indicate a definite trend toward priority of leg length growth in relation to stem length growth, and a definite trend toward synchrony between maximum velocity growth in leg length and in height.

Table 51a TIMING INTERRELATIONS OF APEX OF HEIGHT, OF STEM LENGTH, AND OF LEG LENGTH FOR 67 BOYS (By Number of Cases)

		Relation of Leg Length Apex to Height Apex—Number of Cases			
		Prior	Synchronous	Later	Total
Relation of stem length apex to height apex	Prior	2	8	0	10
	Synchronous	14*	5	4	23
	Later	7†	25‡	2	34
	Total	23	38	6	67

* Five cases had leg length apex prior to puberal growth period for height.
† Four cases had leg length apex prior to puberal growth period for height.
‡ One case had stem following end of puberal growth period for height.

Table 51b TIMING INTERRELATIONS OF APEX OF HEIGHT, OF STEM LENGTH, AND OF LEG LENGTH FOR 67 BOYS (By Percentage of Cases)

		Relation of Leg Length Apex to Height Apex—Percent of Cases			
		Prior	Synchronous	Later	Total
Relation of stem length apex to height apex	Prior	2.98	11.94	.00	14.92
	Synchronous	20.89	7.46	5.97	34.33
	Later	10.45	37.31	2.98	50.75
	Total	34.33	56.72	8.95	100.00

Figures 124a, b, c, d, e, f, g, and h illustrate individual variations in timing relations of apex growth in height, leg length, and stem length.

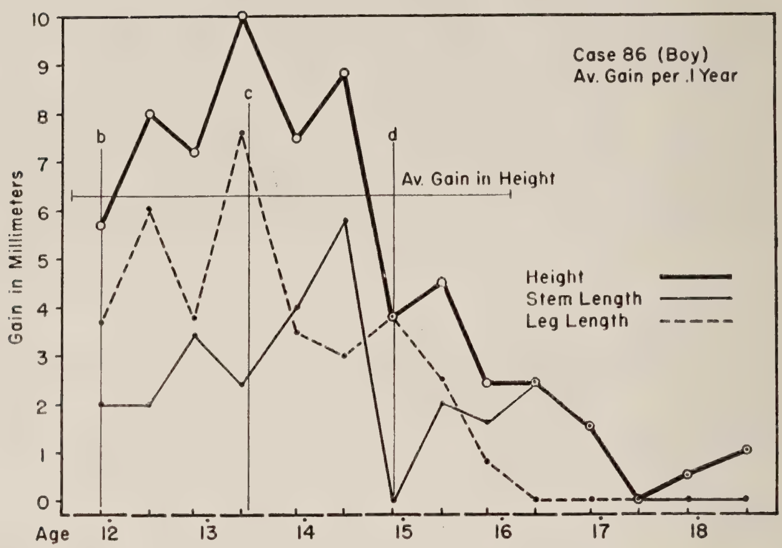


FIGURE 124a. Velocity curves of Case 86 illustrating leg length apex synchronous with and stem length apex following height apex. Of the 67 cases, 37.3 per cent showed this timing relationship.

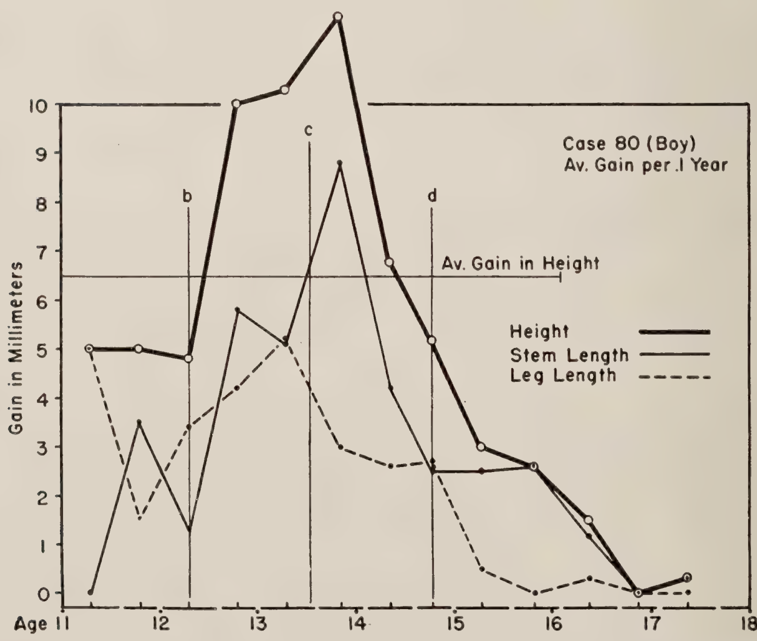


FIGURE 124b. Velocity curves of Case 80 illustrating stem length apex synchronous with and leg length apex prior to height apex. Of the 67 cases, 20.89 per cent showed this timing relationship.

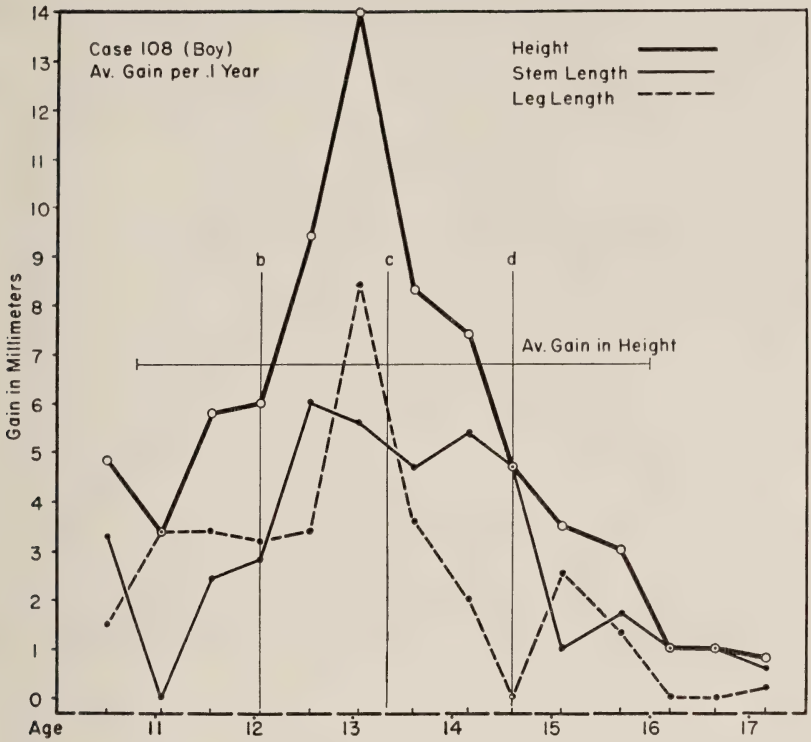


FIGURE 124c. Velocity curves for Case 108 illustrating leg length apex synchronous with and stem length apex prior to height apex. Only eight cases (11.9 per cent) showed this timing relationship.

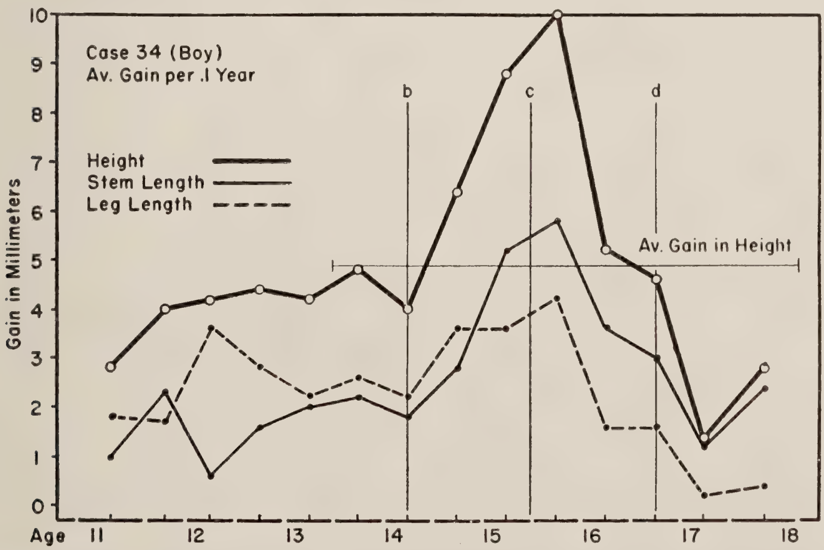


FIGURE 124d. Velocity curves for Case 34 illustrating leg length apex and stem length apex both synchronous with height apex. Only five cases (7.46 per cent) had this complete synchrony.

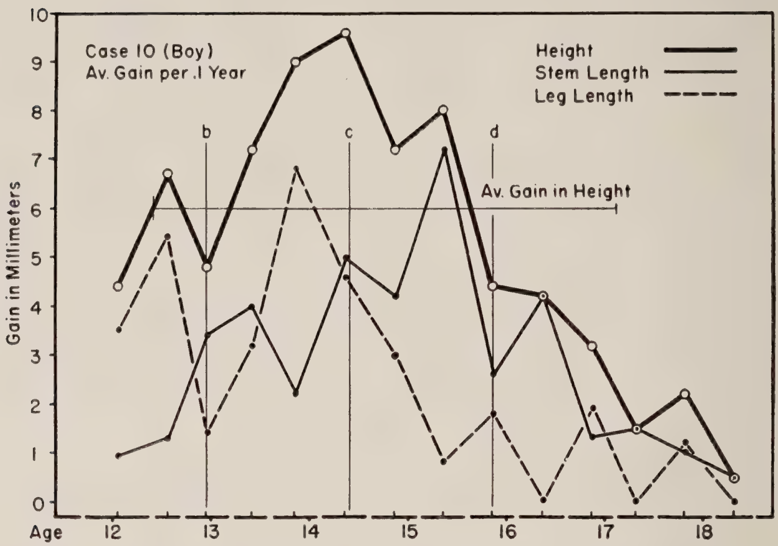


FIGURE 124e. Velocity curves for Case 10 illustrating leg length apex prior to and stem length apex following height apex. Seven cases (10.45 per cent) showed this timing relationship.

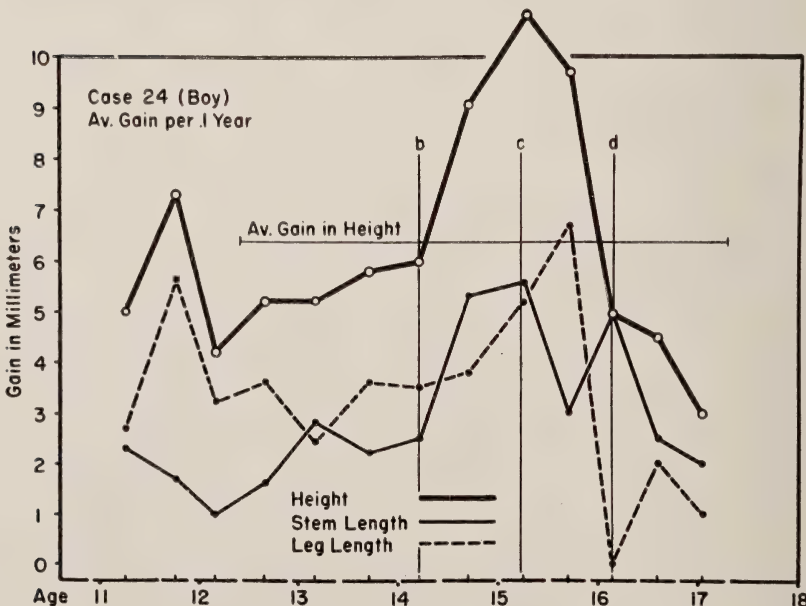


FIGURE 124f. Velocity curves for Case 24 illustrating stem length apex synchronous with and leg length apex following height apex. Only four cases (5.97 per cent) showed this timing relationship.

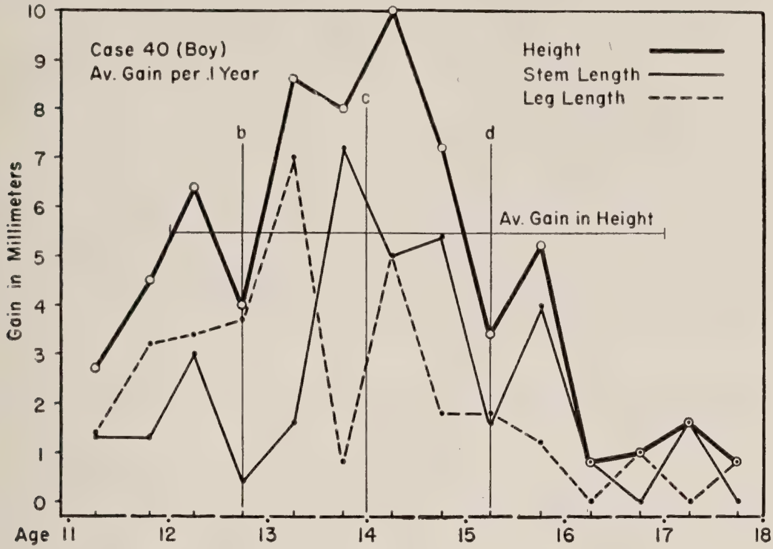


FIGURE 124g. Velocity curves for Case 40 illustrating leg length apex and stem length apex preceding height apex. Only two cases (2.98 per cent) showed this timing relationship.

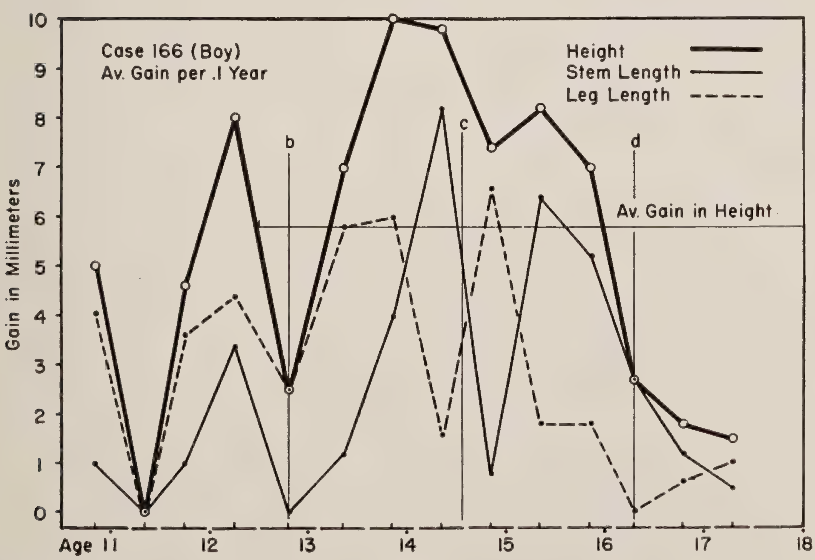


FIGURE 124h. Velocity curves for Case 166 illustrating leg length apex and stem length apex following height apex. There were two cases (2.98 per cent) that showed this relationship.

Section B TIMING RELATIONS IN GROWTH OF SHOULDER WIDTH, HIP WIDTH, AND HEIGHT

TIMING RELATIONS BETWEEN APEX GROWTH OF SHOULDER WIDTH AND HIP WIDTH

In preceding sections the tendency for apex growth velocity in shoulder breadth and apex growth velocity in hip width to occur outside the puberal growth period for height has been noted. This tendency toward dispersion is emphasized by the findings summarized in Table 52.

Table 52 TIMING RELATIONS OF SHOULDER-WIDTH GROWTH APEX TO HIP-WIDTH GROWTH APEX

Relation of Shoulder Width Apex	*Number of Cases*	*Per Cent of 67 Cases*	*Years Difference* Average	*Years Difference* Range
Synchronous with hip width apex	9	13.43		
Preceding hip width apex	22	32.83	1.85	.50–4.05
Preceding puberal onset	9	13.43	2.36	.75–4.05
Preceding hip width apex and following end puberal period	1	1.49	.50	.50
Preceding hip width apex and within puberal period	12	17.90	1.63	.50–3.10
Following hip width apex	36	53.73	1.81	.25–4.50
Following end puberal period	7	10.45	2.86	1.95–4.50
Following hip width apex and within puberal period	29	43.28	1.44	.25–3.75
Within ±.5 year of hip width apex	22	32.83		
Shoulder width apex and hip width apex within puberal period for height	39	58.21		

In only 39 of the 67 cases (58.21 per cent) do both the apex for shoulder-breadth growth and for hip-width growth fall within the puberal growth period for height. In only 22 cases (32.8 per cent) do they occur within a half year of each other; in 9 cases they occur synchronously.

As between shoulder breadth and hip width, the apex velocity sequence shows wide variation. The apex for shoulder breadth precedes that for hip width in 22 cases (32.18 per cent) and follows the apex for hip width in 36 cases (53.73 per cent). The extremes are one case in which the shoulder-breadth apex occurs 4.05 years before the hip-width apex, and one case in which the shoulder-breadth apex occurs 4.50 years after it.

Specimen individual curves illustrating these timing variations are shown in Figures 125a, b, and c.

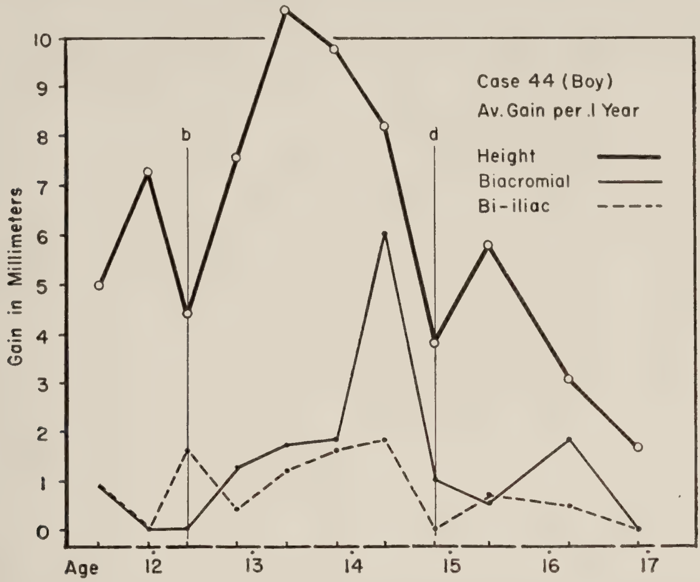


FIGURE 125a. Growth curves of boy (Case 44) in which apex for biacromial growth and apex for bi-iliac growth occur synchronously. Only nine cases (13.43 per cent) had similar timing.

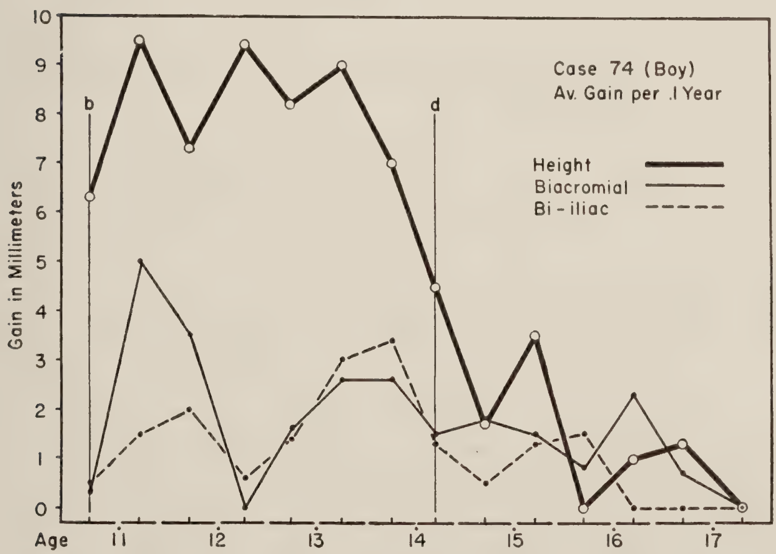


FIGURE 125b. Growth curves of boy (Case 74) in which apex for biacromial growth precedes apex for bi-iliac growth. Twenty-three cases (34.33 per cent) had similar timing.

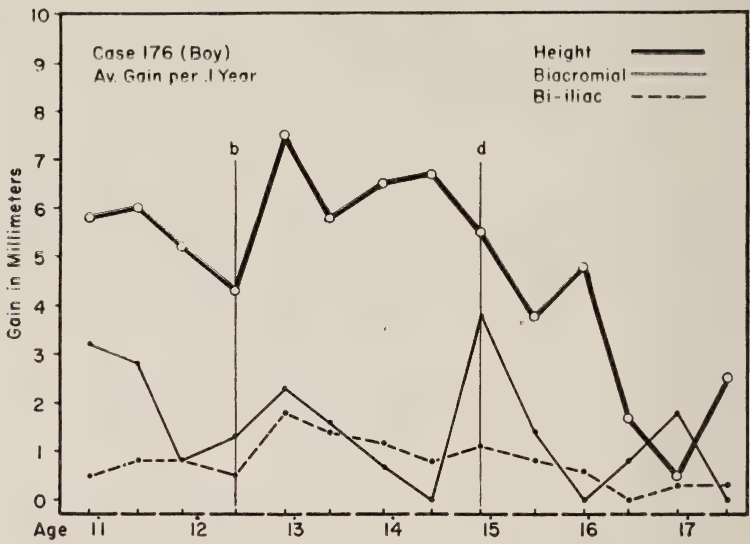


FIGURE 125c. Growth curves of a boy (Case 176) in which apex of biacromial growth follows apex of bi-iliac growth. Thirty-five cases (52.24 per cent) had similar timing.

TIMING INTERRELATIONS OF APEXES OF GROWTH OF SHOULDER WIDTH, HIP WIDTH, AND HEIGHT

The timing interrelations for maximum growth velocity of height, shoulder breadth, and hip width are summarized in Tables 53a and b.

Table 53a TIMING INTERRELATIONS OF APEX OF HEIGHT, BIACROMIAL WIDTH, AND BI-ILIAC WIDTH—67 BOYS BY NUMBER OF CASES

		Relation of Bi-iliac Apex to Height Apex, Number of Cases			
		Prior	Synchronous	Later	Total
Relation of biacromial apex to height apex	Prior	9 *	6 †	9 ‡	24
	Synchronous	2 §	5	3	10
	Later	10 ‖	13 #	10 **	33
	Total	21	24	22	67

* One case had apex biacromial prior to b. Four cases had apex bi-iliac prior to b.
† Four cases had apex biacromial prior to b.
‡ Four cases had apex biacromial prior to b. Two cases had apex bi-iliac following d.
§ One case had apex bi-iliac prior to b.
‖ Five cases had apex bi-iliac prior to b. Four cases had apex biacromial following d.
\# Two cases had apex biacromial following d.
** One case had apex of both biacromial and bi-iliac following d. One case had apex biacromial following d.

Table 53b TIMING INTERRELATIONS OF APEX OF HEIGHT, BI-ACROMIAL WIDTH, AND BI-ILIAC WIDTH—PERCENTAGE OF 67 BOYS

		Relation of Bi-iliac Apex to Height Apex, Per cent of Cases			
		Prior	Synchronous	Later	Total
Relation of biacromial apex to height apex	Prior	13.43	8.95	13.43	37.31
	Synchronous	2.98	7.46	4.48	14.92
	Later	14.92	19.40	14.92	47.76
	Total	31.34	35.82	32.83	100.00

One is impressed again by the variety of patterns. Among the 35.8 per cent of the boys who had their apex of bi-iliac growth synchronous with height apex, the biacromial apex came after height apex in 19.4 per cent of the cases, synchronous with height in 7.5 per cent of the cases, and prior to height apex in 8.9 per cent of the cases. Examples of these different patterns are shown in Figures 126a, b, and c.

Of the 22 boys who had apex of bi-iliac growth following apex of height growth, 9 cases had biacromial growth apex prior to height growth apex, 3 cases had them synchronous, and 10 had biacromial growth apex following apex for height growth.

Among the group of 21 boys who had bi-iliac growth apex prior to height, 10 of them preceded the onset of the puberal growth period. The apex for biacromial growth of these same boys, however, preceded height growth apex in only 9 cases, 2 being synchronous and 10 following height growth apex. Of these 10, there were 4 cases where the biacromial apex was after the end of the puberal growth period.

Section C TIMING INTERRELATIONS OF FIVE SKELETAL MEASUREMENTS

TIMING RELATIONS OF APEX GROWTH

From the separate analyses already presented of the timing of maximum growth velocities for stem length, leg length, shoulder breadth, and hip width in relation to height, it is apparent that in our sample there was wide diversity of pattern. The characteristics and frequencies of these patterns are summarized in Tables 54a and b and presented graphically in Figure 127.

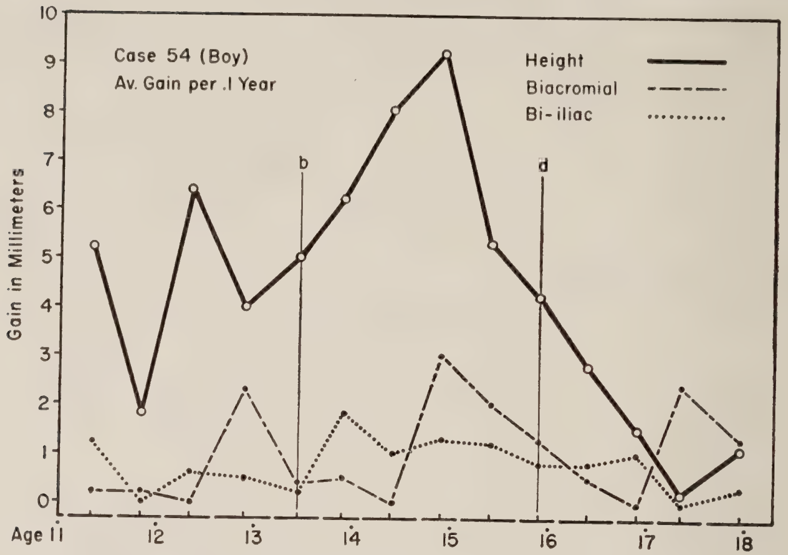


FIGURE 126a

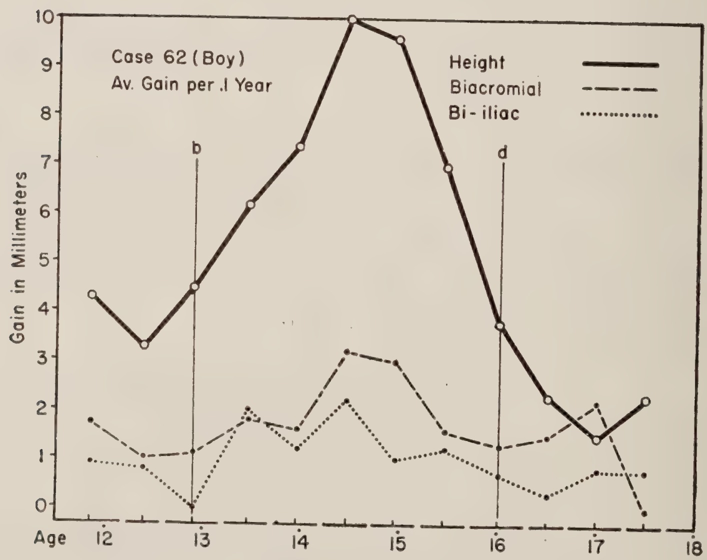


FIGURE 126b

FIGURE 126a, b, and c. Growth curves of three boys (Cases 54, 62, and 220) all of whom had apex of biacromial width synchronous with height apex. However, the bi-iliac apex preceded the height apex in Case 54, was synchronous with it in Case 62, and followed it in Case 220.

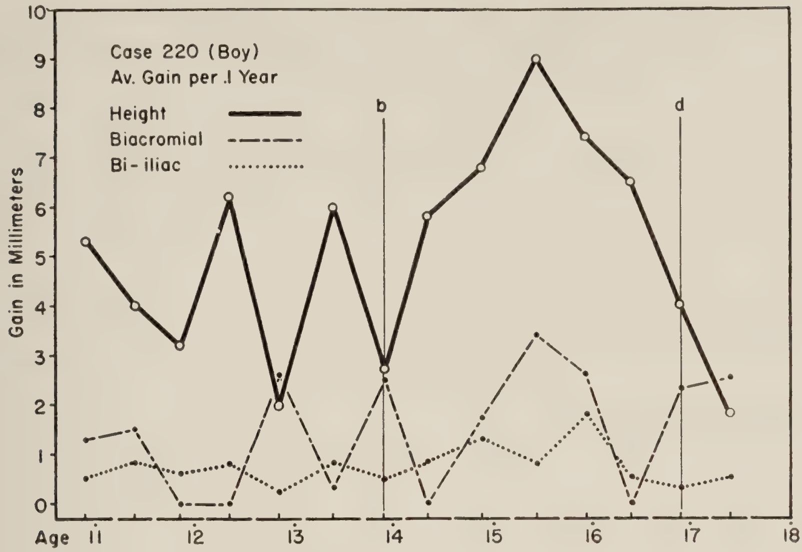


FIGURE 126c

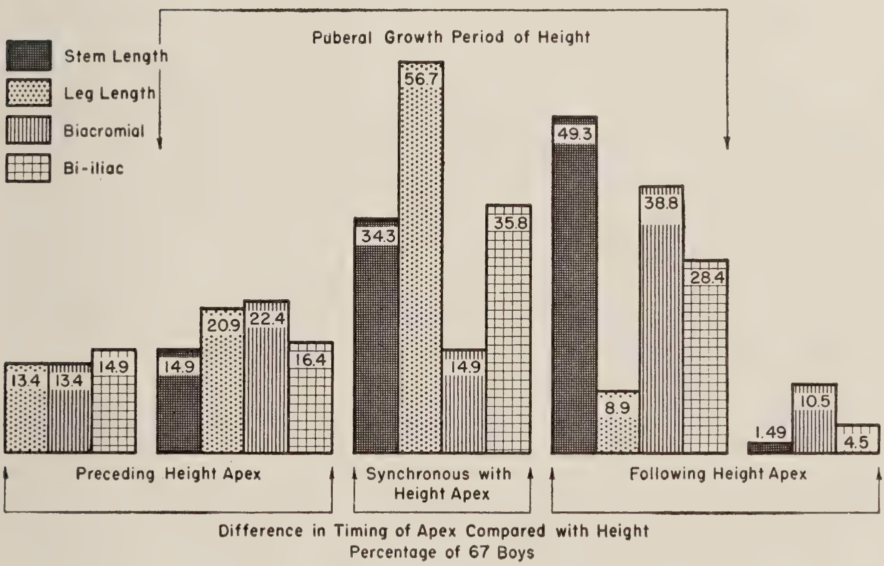


FIGURE 127. Timing relations of apex of growth in stem length, leg length, biacromial width, and bi-iliac width to apex of growth in height for 67 boys.

This figure makes it possible to compare the timing of each of the four apexes with the timing of the apex for height. It shows for each of these the percentage of cases in which the apex occurred before, synchronous with, or following the height apex. It also shows the percentage of each which occurred outside of the puberal growth period for height. This figure is based on Table 54b.

Table 54a SUMMARY OF TIMING RELATIONS OF DIFFERENT APEXES WITH APEX FOR HEIGHT—67 BOYS BY NUMBER OF CASES

Relation with Apex Height	*Stem Length* Number	*Leg Length* Number	*Shoulder Width* Number	*Hip Width* Number
Synchronous	23	38	10	24
Precedes	10	23	24	21
Precedes onset puberal period	0	9	9	10
Precedes but within puberal period	0	14	15	11
Follows	34	6	33	22
Follows end puberal period	1	0	7	3
Follows but within puberal period	33	6	26	19
Within ±.5 year	45	49	26	35
Apex within puberal period	66	58	51	54

Table 54b SUMMARY OF TIMING RELATIONS OF DIFFERENT APEXES WITH APEX FOR HEIGHT—PERCENTAGE OF 67 BOYS

Relation with Apex Height	*Stem Length* Per Cent	*Leg Length* Per Cent	*Biacromial* Per Cent	*Bi-iliac* Per Cent
Synchronous	34.33	56.72	14.92	35.82
Precedes	14.92	34.33	35.82	31.34
Precedes onset puberal period	.00	13.43	13.43	14.92
Precedes but within puberal period	.00	20.89	22.39	16.42
Follows	50.75	8.95	49.25	32.83
Follows end puberal period	1.49	.00	10.45	4.48
Follows but within puberal period	49.25	8.95	38.80	28.36
Within ±.5 year	67.16	73.13	38.80	52.24
Apex within puberal period	98.51	86.57	76.05	80.60

From these tables it appears that among these measures the timing of apex velocity growth for leg length was the most frequently synchronous with that of the height apex (56.7 per cent of the cases); that hip width (35.8 per cent) and stem length (34.3 per cent) synchrony with height occurred in about one third of the cases; that the apex for shoulder breadth was synchronous with the apex for height in only 14.9 per cent of cases.

It is also apparent that the leg length apex frequently precedes height apex (34.3 per cent) but rarely follows height apex (8.9 per cent); that the stem length apex frequently follows height apex (50.79 per cent) but much less frequently precedes it (15.87 per cent); that the shoulder breadth apex occurs somewhat more frequently after height apex (49.25 per cent) than before it (35.82 per cent); that the hip width apex occurs almost as often before (31.3 per cent) as after (32.8 per cent) the height apex.

As among the four dimensions, there is considerable variation in tendency for apex growth to occur during the puberal growth period for height. (See Figure 127.) The apex for stem length occurs within this period in 98.51 per cent of the cases; the apex for leg length in 86.60 per cent; the apex for hip width in 80.60 per cent; the apex for shoulder width in 76.05 per cent.

Figure 127 also supports the conclusion that in only a few cases does the apex for stem length or hip width fall *after* the close of the puberal growth period for height, but that in about one seventh of the cases the apex for leg length *or* for hip width occurs *before* the onset of the period. The shoulder breadth apex occurs before the period in 13.4 per cent and after in 10.5 per cent of the cases.

GROUPING OF GROWTH APEXES

When we analyze further the interrelations of timing among these five manifestations of skeletal growth during adolescence, the diversity of pattern becomes even more impressive. Of the 67 cases there were but 2 in which maximum growth in all five occurred at the same time.[2] There were 2 cases in which apex velocity in these five skeletal measurements showed

Table 55 OCCURRENCE OF APEXES OF HEIGHT, STEM LENGTH, LEG LENGTH, BIACROMIAL WIDTH, AND BI-ILIAC WIDTH —67 BOYS

Number of Points at which Five Apexes Occur	*Number of Cases*	*Per Cent of Cases*	*Number of Different Groupings of Apexes*
1	2	2.98	1
2	8	11.94	6
3	28	41.79	22
4	27	40.30	20
5	2	2.98	2
Total	67	100.00	51

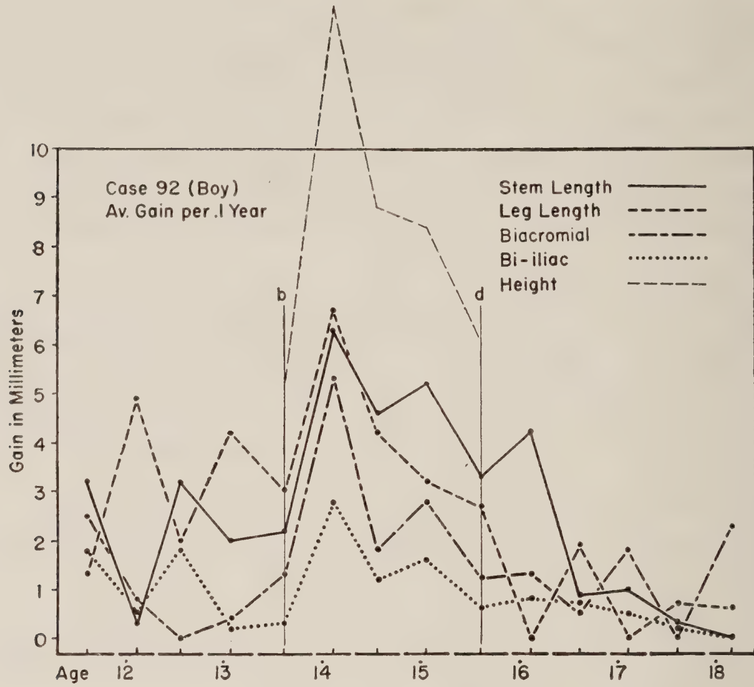


FIGURE 128a

complete asynchrony—no two of them occurring at the same time. The five apexes were grouped at two points in 8 cases, at three points in 28 cases, and at four points in 27 cases.[3] (See Table 55.)

Figures 128a and b show the growth curves for the two cases (Cases 92 and 144) in which the maximum growth occurred synchronously for all five of the dimensions we are discussing. As would be expected, there is a general similarity of growth pattern between these two cases. However, no one who knew these two boys would think of them as similar in physical characteristics. As one can readily see from the photographs in Figure 128c, one boy was unusually tall, while the other was below average in height; one was long-armed and long-legged, while the other was not. The period of puberal growth in height for one (Case 144) started 2.3 years earlier and lasted 1.05 years longer than for the other, and there was a corresponding difference in the timing of the development of the genital organs.

Among the 67 cases there were 51 different arrangements of sequential timing of the five apexes. For example, the 8 cases whose apexes occurred at two different points showed six different arrangements of sequence. For 3 cases (146, 244, and 66) the apex of height, leg length, and bi-iliac

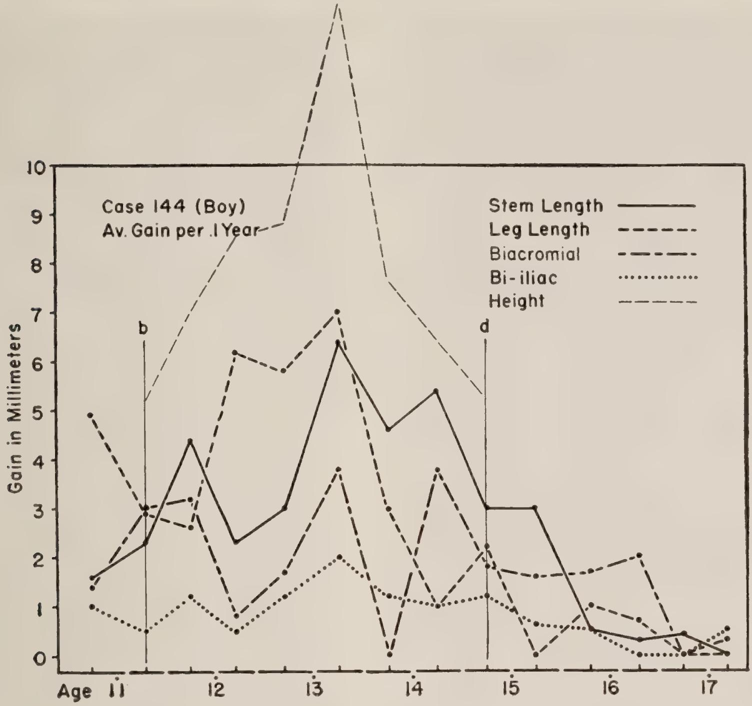
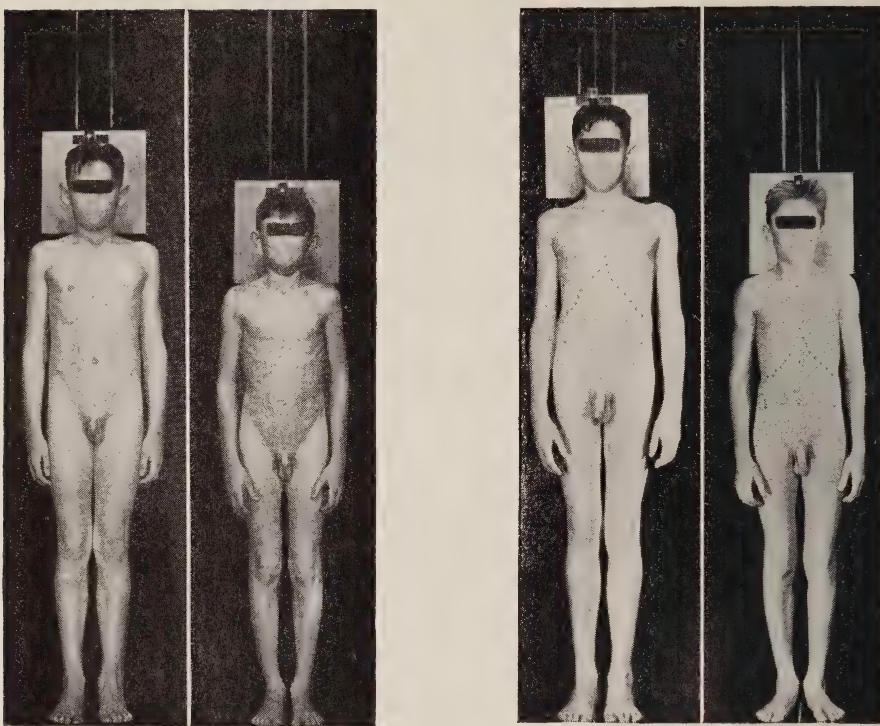


FIGURE 128b

FIGURES 128a and b. Growth curves of the only two boys (Cases 92 and 144) in which maximum growth for five skeletal measurements occurred at the same time. Case 92 began his puberal growth period in height at 13.6 years and finished it 2 years later. Case 144 began at 11.3 years and finished 3.05 years later. The apexes for growth occurred at 14.1 years for Case 92 and 13.2 years for Case 144. See photographs in Figure 128c.

occurred together, followed by stem length and biacromial apexes. The 5 remaining cases each had a different arrangement. Of the 51 different patterns: 3 patterns include three cases each, 10 patterns include two cases each, and 38 patterns include one case each. Where the five apexes occurred at two points there were 6 different patterns. There were 22 different patterns among the cases in which the five apexes occurred at three different points and 20 different patterns where the apexes occurred at four different points.[4]

It is impossible to give a sample growth curve of each of the 51 different timing patterns for these five dimensions. We would like to do this because only through a study of the actual growth curves can one be convinced of the diversity in human growth. However, we have selected one pattern from each group in Table 55 and present the growth curves in Figures 128a and b (apexes occurring at one point), Figure 129a (apexes occurring at two points), Figure 129b (apexes occurring at three points),



Case 144	Case 92	Case 144	Case 92
C.A. 11.3	13.6	13.2	14.1

Puberal onset — Puberal apex

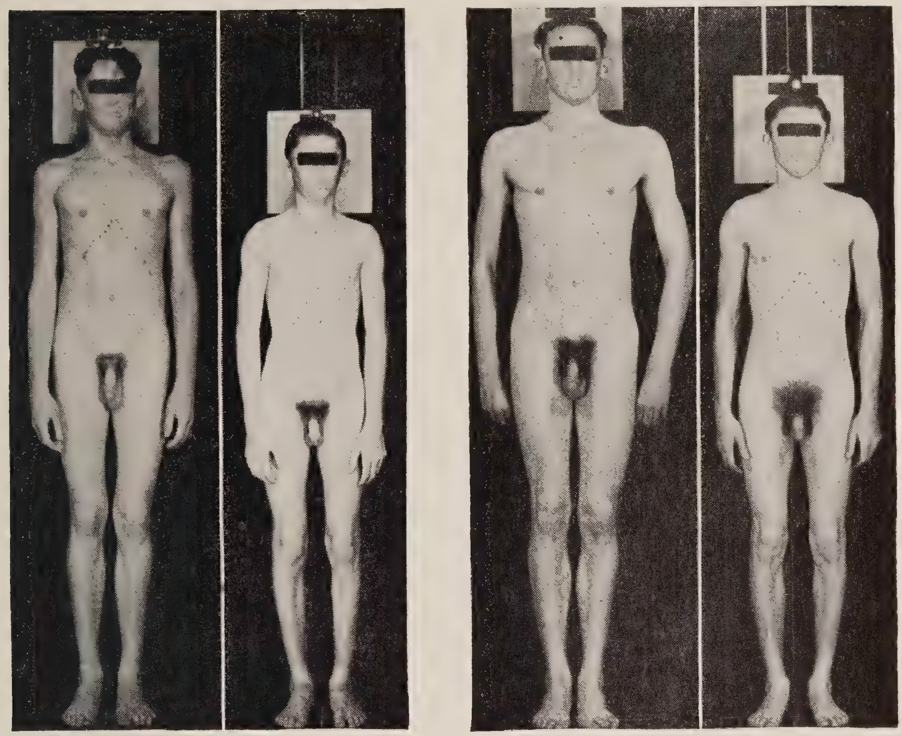
FIGURE 128c.

Figures 129c and d (apexes occurring at four points), and Figure 129e (apexes occurring at five points).

SYNCHRONOUS APEX CLUSTERS

Even when the apexes of two or more dimensions occur synchronously, the remaining apexes may have a number of different arrangements in time. In Table 56 we have tried to show this by grouping those cases which show synchrony of apex velocity for the same measures and indicating the timing relations of the measures which reach apex before or after the synchronous cluster. Among our 67 boys there were 18 different cluster patterns, including two, three, or four synchronous apexes.

Thus it can be seen (in Cluster Pattern 4A, Table 56) that there are two cases in which all apexes are synchronous except shoulder width, but in Case 60 shoulder width occurs prior to the cluster, and in Case 96 after the cluster.



Case 144	**Case 92**	**Case 144**	**Case 92**
C.A. 14.3	15.6	17.4	18.4
Puberal end		Late adolescence	

FIGURE 128c. Puberal growth apex in height, stem length, leg length, shoulder breadth, and hip width occurred synchronously in each of these two cases. Some of the *differences* between the two boys are obvious from the photographs.

Similarly there are two cases where all apexes are synchronous except stem length (Cluster Pattern 4B) with Case 108 having stem length prior to the cluster and Case 88 having it following the cluster.

There are eleven cases which show an apex cluster, including height, leg length, and hip width (Cluster Pattern 3A), but there are six different timing arrangements for the remaining apexes of stem length and shoulder width.

Of the twelve cases in which height apex and stem length apex are synchronous (Cluster Pattern 2A) only three pairs of them show the same sequence pattern for all five measures, giving nine different patterns for twelve cases.

The eighteen cases in which height apex and leg length apex are synchronous (Cluster Pattern 2B) have thirteen different patterns of sequence.

Table 56 COMPARISON OF TIMING RELATIONS OF ASYNCHRONOUS APEXES WITH APEX CLUSTER—65 CASES *

Case	*Apex Prior to Cluster*		*Apex Cluster*	*Apex Following Cluster*			*Cluster Pattern*†
92, 144			Ht., S.L., L.L., Bi-ac., Bi-il.				5
96			Ht., S.L., L.L., Bi-il.	Bi-ac.			4A
60	Bi-ac.		Ht., S.L., L.L., Bi-il.				
88			Ht., L.L., Bi-ac., Bi-il.	S.L.			4B
108	S.L.		Ht., L.L., Bi-ac., Bi-il.				
62	L.L.		Ht., S.L., Bi-ac., Bi-il.				4C
176, 242			Ht., L.L., Bi-il.	Bi-ac.	S.L.		3A
32, 100, 190			Ht., L.L., Bi-il.	S.L.	Bi-ac.		
30		S.L.	Ht., L.L., Bi-il.	Bi-ac.			
58, 64	Bi-ac.	S.L.	Ht., L.L., Bi-il.				
66, 146, 244			Ht., L.L., Bi-il.	S.L., Bi-ac.			
112			Ht., L.L., Bi-ac.	S.L.	Bi-il.		3B
72		Bi-il.	Ht., L.L., Bi-ac.	S.L.			
80	Bi-ac.	L.L.	Ht., S.L., Bi-il.				3C
82, 180		L.L.	Ht., S.L., Bi-il.	Bi-ac.			
130			Ht., S.L., Bi-il.	L.L.	Bi-ac.		
54	L.L.	Bi-il.	Ht., S.L., Bi-ac.				3D
34‡		Bi-il.	Ht., S.L., L.L.	Bi-ac.			3E
106			Ht., S.L.	L.L., Bi-il.	Bi-ac.		2A
8		L.L., Bi-il.	Ht., S.L.	Bi-ac.			
44		L.L.	Ht., S.L.	Bi-ac., Bi-il.			
184	Bi-il.	L.L., Bi-ac.	Ht., S.L.				
164		L.L.	Ht., S.L.	Bi-ac.	Bi-il.		
110, 236	L.L.	Bi-il.	Ht., S.L.	Bi-ac.			
24, 104	Bi-il.	Bi-ac.	Ht., S.L.	L.L.			
216, 224	Bi-il.	L.L.	Ht., S.L.	Bi-ac.			
26		L.L.	Ht., S.L.	Bi-il.	Bi-ac.		
78, 136, 234	Bi-il.	S.L.	Ht., L.L.	Bi-ac.			2B
50, 218			Ht., L.L.	Bi-ac., Bi-il.	S.L.		
292		Bi-ac.	Ht., L.L.	S.L., Bi-il.			
304			Ht., L.L.	S.L., Bi-il.	Bi-ac.		
120		Bi-il.	Ht., L.L.	S.L., Bi-ac.			
116			Ht., L.L.	S.L.	Bi-il.	Bi-ac.	
134			Ht., L.L.	Bi-il.	Bi-ac.	S.L.	
52, 86		Bi-ac.	Ht., L.L.	Bi-il.	S.L.		
74, 230		Bi-ac.	Ht., L.L.	S.L.	Bi-il.		
154		Bi-il.	Ht., L.L.	S.L.	Bi-ac.		
18	Bi-ac.	Bi-il.	Ht., L.L.	S.L.			
84	Bi-ac.	S.L.	Ht., L.L.	Bi-il.			
36	Bi-il.	Bi-ac.	Ht., L.L.	S.L.			
168		LL., Bi-ac.	Ht., Bi-il.	S.L.			2C
40	L.L.	S.L., Bi-ac.	Ht., Bi-il.				
220		L.L.	Ht., Bi-ac.	S.L.	Bi-il.		2D
212			Ht., Bi-ac.	L.L., Bi-il.	S.L.		

* Two cases had no clusters. (Cases 166 and 294).

† In designating cluster patterns the number refers to number of apexes which occur in cluster, the letter to the specific measurements in a cluster.

‡ This case (34) could not be grouped with any other case. In the four other cases where Ht., S.L., and L.L. were synchronous, two cases had all five measures synchronous (Cases 92 and 144) and two cases had four measures synchronous (Cases 54 and 62.)

Table 56 (*Continued*) COMPARISON OF TIMING RELATIONS OF ASYNCHRONOUS APEXES WITH APEX CLUSTER—65 CASES *

Case	*Apex Prior to Cluster*	*Apex Cluster*	*Apex Following Cluster*	*Cluster Pattern*†
168§		L.L., Bi-ac.	Ht., Bi-il. S.L.	2E
10		L.L., Bi-ac.	S.L. Ht. Bi-il.	
68		L.L., Bi-ac.	Ht. Bi-il. S.L.	
250	Bi-il.	L.L., Bi-ac.	Ht. S.L.	
184§	Bi-il.	L.L., Bi-ac.	Ht., S.L.	
8§		L.L., Bi-il.	Ht., S.L. Bi-ac.	2F
106§	Ht., S.L.	L.L., Bi-il.	Bi-ac.	
212§	Ht., Bi-ac.	L.L., Bi-il.	S.L.	
150		L.L., Bi-il.	Ht. Bi-ac. S.L.	
40*§	L.L.	S.L., Bi-ac.	Ht., Bi-il.	2G
120§	Bi-il. Ht., L.L.	S.L., Bi-ac.		
206	L.L. Ht., Bi-ac.	S.L., Bi-il.		2H
292§	Bi-ac. Ht., L.L.	S.L., Bi-il.		
50, 218§	Ht., L.L.	Bi-ac., Bi-il.	S.L.	2I
44§	L.L. Ht., S.L.	Bi-ac., Bi-il.		

* Two cases had no clusters (Cases 166 and 294).
§ Cases marked § have been grouped under two different dual cluster patterns.

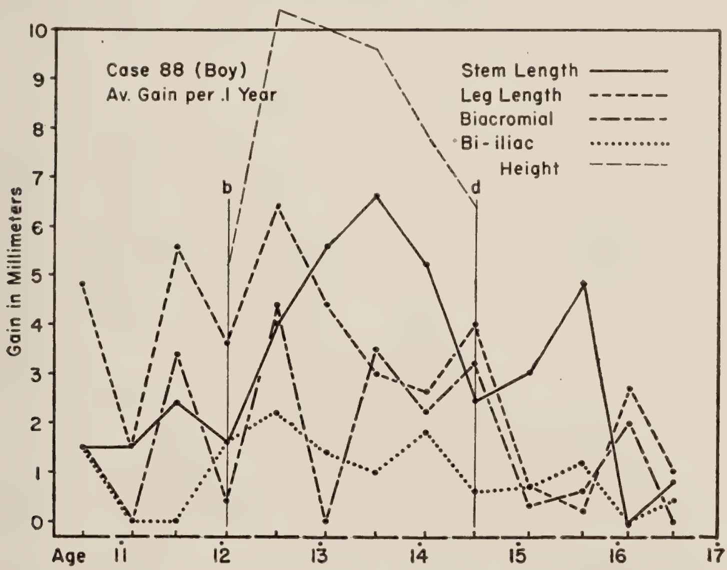


FIGURE 129a. Growth curves of Case 88 in which the apexes of the five dimensions occurred at *two* points. Stem length was the only one not synchronous. There were eight cases which showed six different patterns of this type of timing. (See Table 55 and Appendix O.)

The analysis shows thirteen other cluster patterns containing from 1 to 5 cases each, but of the 21 different cases included only three pairs show the same sequence patterns for the total five apexes.

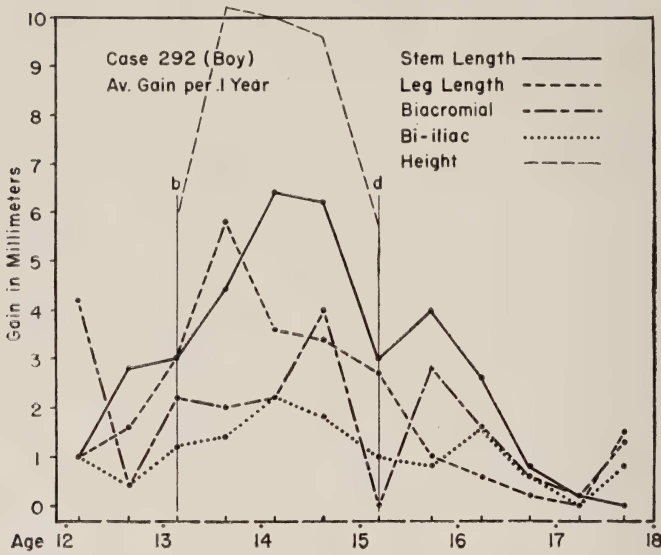


FIGURE 129b. Growth curves of Case 292 in which the apexes of the five dimensions occurred at *three* points. There were 28 cases which showed 22 different patterns of this type of timing. (See Table 55 and Appendix O.)

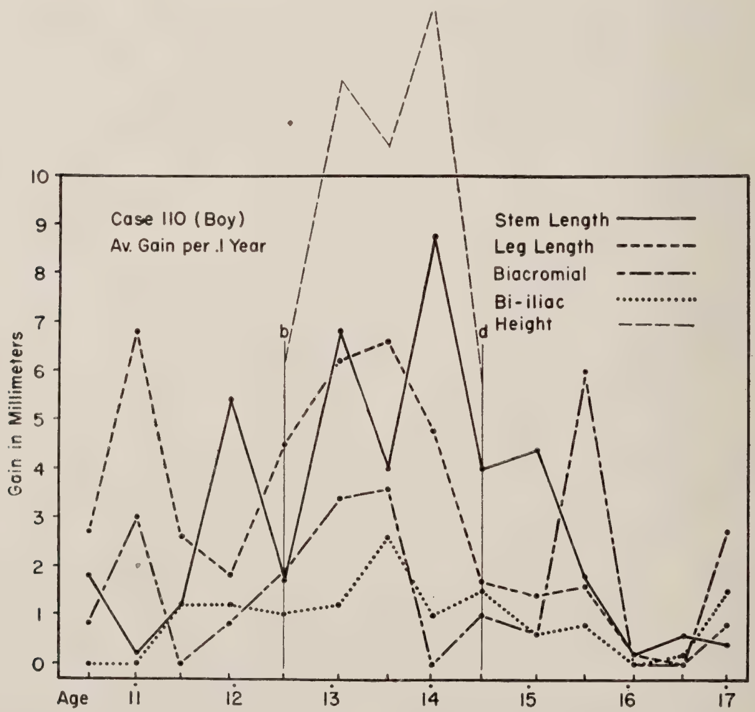


FIGURE 129c. In Case 110 the apexes of the five growth curves occurred at four different times, stem length and height occurring synchronously. There were 27 cases with 20 different patterns of this timing. (See Table 55 and Appendix O.)

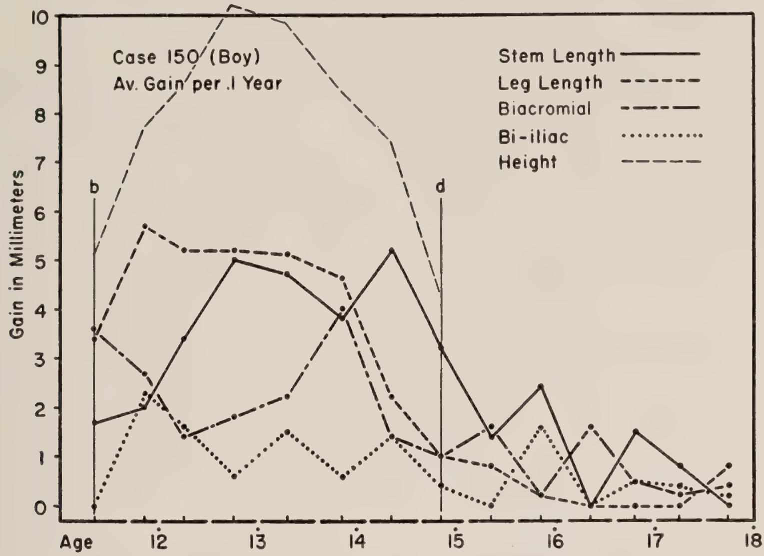


FIGURE 129d. The growth curves of Case 150 illustrate another timing pattern in which the five curves had their apexes at four different times. In this case leg length and bi-iliac width had their apexes of growth synchronously.

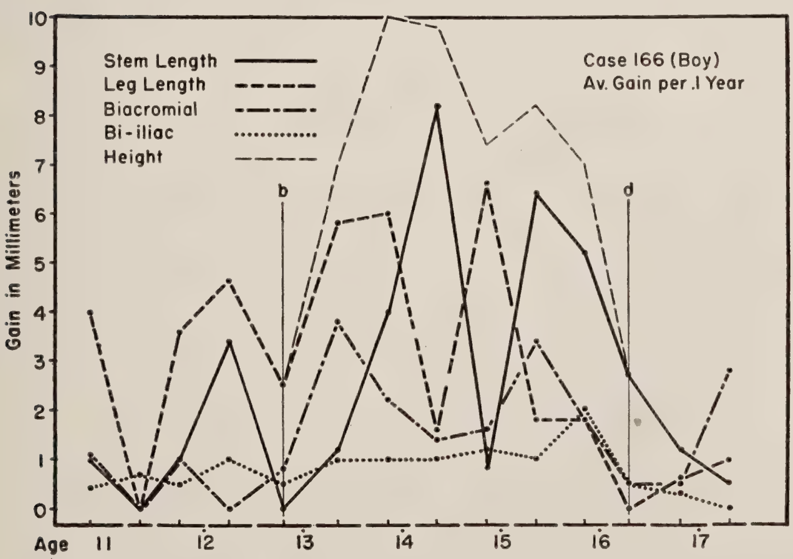


FIGURE 129e. Growth curves of five skeletal measurements of Case 166. This is one of the two cases in which all five apexes occurred at different points in time. (See Table 55 and Appendix O.)

Table 57 ORDER OF APPEARANCE OF APEXES

Apex Order	*Leg Length Cases*		*Stem Length Cases*		*Biacromial Width Cases*		*Bi-iliac Width Cases*		*Height Cases*		*Total*	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Apexes	Cases
First	35	52.24	7	10.45	21	31.34	29	43.28	21	31.34	113	67
Second	21	31.34	27	40.30	18	26.86	17	23.37	25	37.31	108	65
Third	8	11.94	24	35.82	18	26.86	12	17.90	20	29.85	82	57
Fourth	3	4.48	9	13.43	10	14.92	8	11.94			30	29
Fifth							1	1.49	1	1.49	2	2
Total	67		67		67		67		67			

THE ORDER OF APPEARANCE OF THE SEVERAL APEXES

In the chapters dealing with our findings regarding adolescent growth in stem length, leg length, shoulder width, and hip width, we have included consideration of the timing relation which the growth velocity apex of each bore to the height growth velocity apex. In this chapter we have shown the wide variety of sequential patterns and the many cluster patterns represented by our sample. Table 57 summarizes our data concerning the *order* in which the five growth apexes occurred.

From this table we see that, despite the heterogeneity of the patterns, there were a few significant tendencies for the group. The leg length apex was the first or one among the first to occur in 52.24 per cent of the cases; it was among the first or second to occur in 83.58 per cent. Stem length occurred first or among the first in only 10.45 per cent of the cases; its most frequent ordinal position was second (40.30 per cent), but it occurred almost as frequently in third place (35.82 per cent). The order of the shoulder width apex was widely and rather evenly distributed; it was first or among the first in 31.34 per cent, among the second in 26.86 per cent, among the third in 26.86 per cent, and among the fourth in 14.92 per cent. The hip width apex showed an ordinal tendency quite similar to the leg length apex, although it was slightly less apt to appear in first or second and a little more apt to appear in third or fourth position. As would be expected from its components, height apex occurred first, second, or third in 98.51 per cent of the cases.

Section D AN INDEX OF APEX ASYNCHRONY

Upon the hypothesis that the degree of apex asynchrony among the several measures of skeletal growth may be associated with other variables in the somatic development patterns or even with variation in emotional response to the adolescent experience, it seemed appropriate to devise an index of apex asynchrony which would be easier to use than the somewhat bewildering array of apex cluster patterns shown in Table 56 and which might be helpful in discovering any such association of variables. The index was obtained as follows: The timing differences between the apex for height and the apexes for the other four skeletal measures were multiplied by 100, squared, added, divided by 4, and the square root of this quotient taken as the *Apex Asynchrony Index*.[5] In this computation no distinction was made between apexes occurring before and apexes occurring after the height apex. The index values obtained ranged from 0 for two cases in which all five apexes were synchronous to 203 for the case in

							84								
					44		50	166							
					234		250	150							
					146		134	10							
				218	66		74	206			220				
				190	212	54	216	32			120				
			36	180	106	112	294	184			230	164			
		108	82	130	52	292	86	136		168	8	110	24		
	144	96	244	242	344	58	116	80	236	72	64	224	18		
	92	62	30	88	40	34	104	60	154	78	100	26	176	68	
Index	0	15	30	45	60	75	90	105	120	135	150	165	180	195	210

FIGURE 130. Distribution of 67 cases according to Apex Asynchrony Index: range, 0 to 203; mean, 97.20; standard deviation, 47.36; median 93.75; Q_1, 62.33; Q_3, 135.75.

which the apexes were most widely scattered in time. The distribution of our 67 cases according to this Apex Asynchrony Index is shown in Figure 130.

In Figures 128a and b on pages 230-31 will be found the skeletal growth profiles for the two cases (92 and 144) which exhibited complete apex synchrony for the five skeletal measures. Figure 129b on page 236 shows five growth profiles for a boy (Case 292) whose Apex Asynchrony Index was slightly below the mean for the group. Figure 129c on page 236 shows the profiles for a boy (Case 110) with a high degree of apex asynchrony. In his case the high index resulted from a leg length apex early in the prepuberal period and a shoulder width apex in the postpuberal period. During the puberal growth period for height his pattern of skeletal growth tended toward synchrony of skeletal apexes.

In order to determine which apex or combination of apexes had most frequently caused a high Apex Asynchrony Index, we analyzed the growth profiles for the seventeen cases which fell at or above Q_3 in the distribution in Figure 130. We found that the patterns were:

	Number of Cases	*Per Cent of Cases*
Prepuberal apexes for leg length, biacromial, bi-iliac	2	11.76
Prepuberal apexes for leg length, biacromial	4	25.56
Prepuberal apexes for leg length, bi-iliac	1	5.88
Prepuberal apex for leg length	1	5.88
Prepuberal apex for biacromial	2	11.76
Prepuberal apex for bi-iliac	2	11.76
Prepuberal apex for bi-iliac, postpuberal apex for biacromial	1	5.88
Postpuberal apex for biacromial	2	11.76
Postpuberal apex for bi-iliac	1	5.88
Postpuberal apex for stem length	1	5.88
	17	100.00

It will be noted that no pattern was predominantly responsible for high index of apex asynchrony. However, there was a definite tendency for those cases which displayed very early leg length apexes to show, also, early apexes for biacromial width or bi-iliac width or both. This group included seven (41.20 per cent) of the seventeen cases. It is noteworthy that in only one case was stem length apex asynchrony responsible for the high index. The table shows that a high Apex Asynchrony Index is usually due to prepuberal apexes (76.44 per cent).

THE RELATION OF VARIATION IN APEX ASYNCHRONY TO OTHER GROWTH VARIABLES

Because the upper quartile group in the distribution by Apex Asynchrony Index (Figure 130) seemed to include an undue number of boys whose adolescent growth varied remarkably in one respect or another, we hoped to find significant correlations for the sample between apex asynchrony and other variables. But in this we were disappointed. The correlations found are shown in Table 58.

Table 58 CORRELATION OF ASYNCHRONY INDEX WITH OTHER GROWTH PHENOMENA—67 BOYS

Asynchrony Index with	r.	P.E.
Subcutaneous tissue at b	−.162	.080
Chronological age at b	−.108	.081
Chronological age at d	−.019	.081
Duration b–d	+.140	.081
Rate puberal gain in height	−.224	.078
Strength gain b–d	−.012	.082
Chronological age at P_1	−.136	.081

We must conclude, therefore, that the asynchrony found among the apexes of skeletal growth during adolescence was not significantly related to precocity, retardation, the duration of the puberal period, the rate of gain in height or strength during that period, or the age at which the spurt of glans penis growth commenced (P_1).

SUMMARY

In this chapter some of the timing relations of the growth of height, stem length, leg length, biacromial width, and bi-iliac width have been analyzed.

For most boys the maximum growth of these measurements of body length and body width occurred within the puberal growth period for height. The percentage ranged from 98.5 per cent for stem length to 76.0 per cent for biacromial width. In the cases where the apex did not occur within the puberal height period, the tendency for stem length apex was to follow and for leg length apex and bi-iliac width apex to precede, but biacromial width apex showed about equal tendency to precede or follow the puberal growth period for height.

In over half of the cases leg length apex occurred synchronously with height apex; the apexes for stem length and bi-iliac width each occurred synchronously with height apex in about one third of the cases, but biacromial apex was synchronous in only one seventh of the cases. When not synchronous with height apex, stem length apex usually followed, leg length apex usually preceded, bi-iliac apex had equal tendency to occur before or after, and biacromial apex had a somewhat greater tendency to follow height apex.

One is impressed again with the extent of variability among the 67 boys studied. Five sequential areas of growth can be designated in relation to the height apex: (1) preceding puberal onset, (2) between onset and height apex, (3) synchronous with height apex, (4) between height apex and end, and (5) following puberal end. Stem length apex occurred in all areas except No. 1; leg length apex in all areas except No. 5; bi-iliac apex in all except No. 5; biacromial apex in all areas.

For over eighty per cent of the boys, the apexes of these five skeletal measures occurred at three or four points, but there were 51 different arrangements of sequential timing.

An index of apex asynchrony was devised, and this index was correlated with a number of other growth variables. There was none of these variables which showed any significant statistical correlation with the index. This, however, does not preclude the possibility of significant relations with other aspects of development not analyzed in this study.

The order of appearance of the five apexes was analyzed. There was a strong tendency for leg length apex to occur either first or second (over 80 per cent), for stem length apex to occur either second or third, and, as would naturally follow, for height apex to occur either first, second, or third in the series. Both of the width measurements were more variable, but for each the apex occurred in 85 per cent of the cases in first, second, or third place.

FOOTNOTES FOR CHAPTER VIII

[1] Bean, R. B.: "The Pulse of Growth in Man." *Anat. Rec.*, **28:**45–61, 1924.

[2] That is, during the same interexamination period.

[3] The detail of this sequence pattern analysis is presented in Appendix O.

[4] The patterns found among these 67 boys can be compared with the mathematical possibility that five variables in two piles can give thirty different arrangements; in three piles can give a hundred and fifty. The boys' patterns were one fifth of the mathematical possibility for Group II and one seventh of the mathematical possibility for Group III. The wide diversity of individual growth patterns in the sequence of the occurrence of the five apexes is readily seen in the data shown in Appendix O.

[5] In 19 of the 67 cases two apexes other than the height apex occurred together; in no case did more than two apexes occur together except when synchronous with apex height.

Chapter IX SKELETAL AGE IN RELATION TO HEIGHT GROWTH

SINCE increase in height is almost entirely due to bone growth, it seems reasonable to expect close correspondence between specific developmental points in height growth and specific points in skeletal development as determined by appraisal of X-ray photographs. In this section we present our findings concerning this relationship.

The determinations of skeletal age [1] for our sample of 67 boys were not made until a majority of them had passed their apex growth in height, but fortunately data concerning skeletal age are available from another sample studied before and during the puberal growth period. By combining the findings from the two samples it has been possible to analyze the relations of skeletal age ratings to the onset, the mid-point, and the close of the puberal period for height.[2]

The skeletal age ratings were made at six month intervals from roentgenograms of the left hand and the left knee, using the technique introduced by T. Wingate Todd and his associates.[3]

Our findings support the conclusion advanced by Bayley [4] that skeletal age corresponds more closely than chronological age to other indicators of somatic maturity. Our data are summarized with relation to this point in Tables 59, 60, and 61.

From Table 59 it will be seen that for a sample of 21 boys both the mean chronological age and the mean skeletal age at the onset (b) of the puberal growth period for height fell at thirteen years. But the range of variation from the mean was 2.25 years for chronological age, 1.00 year for skeletal age.

Table 60 summarizes the distribution of 48 cases by skeletal age and chronological age at the mid-point (c) of the puberal growth period for height; Table 61 shows the distribution of 89 cases at the end (d) of that period.

From the data presented it is evident that for about 75 per cent of the cases there was close correspondence between height development and skeletal development, but that in the remaining 25 per cent the tendency

Table 59 DISTRIBUTION OF 21 BOYS, AT THE ONSET OF THE PUBERAL GROWTH PERIOD FOR HEIGHT

(a) By Skeletal Age in Relation to Mean Skeletal Age, and (b) by Chronological Age in Relation to Mean Chronological Age. The Mean Skeletal Age Was 13.0 Years; the Mean Chronological Age Was 13.04 Years.

	(a) *Skeletal Age*		(b) *Chronological Age*	
	Number of Cases	Per Cent of 21 Cases	Number of Cases	Per Cent of 21 Cases
Within ± .25 year of mean	12	57.14	6	28.57
" " .50 " " "	16	76.19	6	28.57
" " .75 " " "	19	90.48	14	66.67
" " 1.00 " " "	21	100.00	16	76.19
" " 1.25 years " "			17	80.95
" " 1.50 " " "			18	85.71
" " 1.75 " " "			20	95.24
" " 2.00 " " "			20	95.24
" " 2.25 " " "			21	100.00

Table 60 DISTRIBUTION OF 48 BOYS AT THE MID-POINT (c) OF THE PUBERAL GROWTH PERIOD FOR HEIGHT

(a) By Skeletal Age in Relation to Mean Skeletal Age, and (b) by Chronological Age in Relation to Mean Chronological Age. The Mean Skeletal Age Was 13.75; the Mean Chronological Age Was 14.25.

	(a) *Skeletal Age*		(b) *Chronological Age*	
	Number of Cases	Per Cent of 48 Cases	Number of Cases	Per Cent of 48 Cases
Within ± .25 year of mean	32	66.67	19	39.16
" " .50 " " "	38	79.17	24	50.00
" " .75 " " "	45	93.67	34	70.83
" " 1.00 " " "	48	100.00	42	87.50
" " 1.25 years " "			44	91.67
" " 1.50 " " "			44	91.67
" " 1.75 " " "			48	100.00

Table 61 DISTRIBUTION OF 89 BOYS AT THE END (d) OF THE PUBERAL GROWTH PERIOD FOR HEIGHT

(a) By Skeletal Age in Relation to Mean Skeletal Age, and (b) by Chronological Age in Relation to Mean Chronological Age. The Mean Skeletal Age Was 15.41; the Mean Chronological Age Was 15.37.

	Skeletal Age		*Chronological Age*	
	Number of Cases	Per Cent of 89 Cases	Number of Cases	Per Cent of 89 Cases
Within ± .25 year of mean	51	57.30	25	28.09
" " .50 " " "	70	78.65	46	51.68
" " .75 " " "	81	91.01	60	67.42
" " 1.00 " " "	89	100.00	68	76.40
" " 1.25 years " "			78	87.64
" " 1.50 " " "			87	97.75
" " 1.75 " " "			88	98.87
" " 2.00 " " "			88	98.87
" " 2.25 " " "			89	100.00

toward correspondence was not so strong. At all three points in height development the range of variation in chronological age was approximately twice as great as the range in skeletal age.

Although the number of cases differ on which data are available for skeletal age and chronological age at the four developmental points for height, we can compare the means:

	Mean Sk. A.	Mean C. A.
prepuberal (b — 3)	11.77 (18 cases)	11.51 (81 cases)
puberal onset (b)	13.00 (21 cases)	12.76 (81 cases)
puberal end(d)	15.50 (86 cases)	15.35 (83 cases)
postpuberal (d + 3)	16.75 (78 cases)	16.60 (83 cases)

We have chosen two boys to illustrate different relations between skeletal age and height development. Case B 15 was a boy who reached all four developmental points in height about a half year before the mean chronological age. However, in skeletal age he was exactly at the mean except at the puberal onset when his skeletal age was .25 years less than the mean. Since the mean at this point was computed on only 21 cases this discrepancy is probably not significant. Case B 15, then, is a boy who was earlier than the average in his height development, but this was not reflected in

his skeletal age ratings. However, the relation of his skeletal age and his height age remained relatively constant throughout the adolescent period. (See Figures 131a and b.)

Case B 50 was a year older in chronological age than the average boy at the first two developmental points in height and about average at the latter two points. His skeletal age, also, at b — 3 and at b was above the mean.[5] However, at d and at d + 3 he was below the mean. Thus Case B 50 showed less consistency of correspondence between the two indicators of maturity than Case B 15. (See Figures 132a and b.)

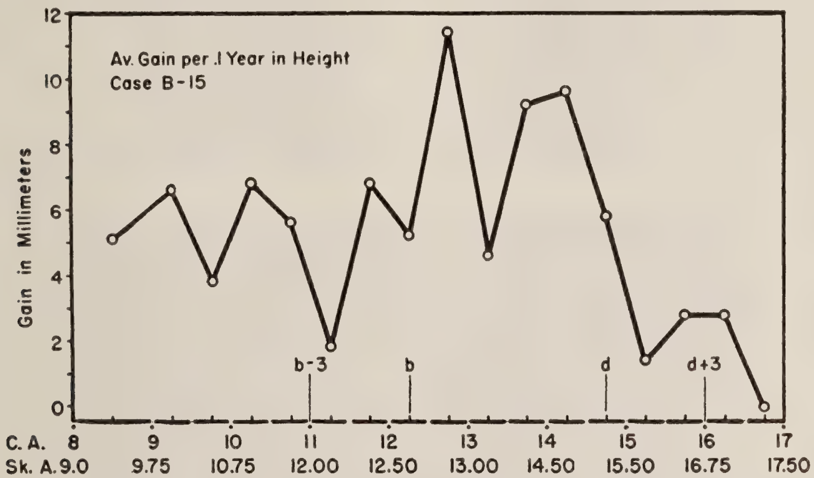


FIGURE 131a. This figure shows the height growth profile for Case B15 whose X-ray photographs are shown in Figure 131b, and indicates the relation between skeletal age and chronological age at the developmental points for height.

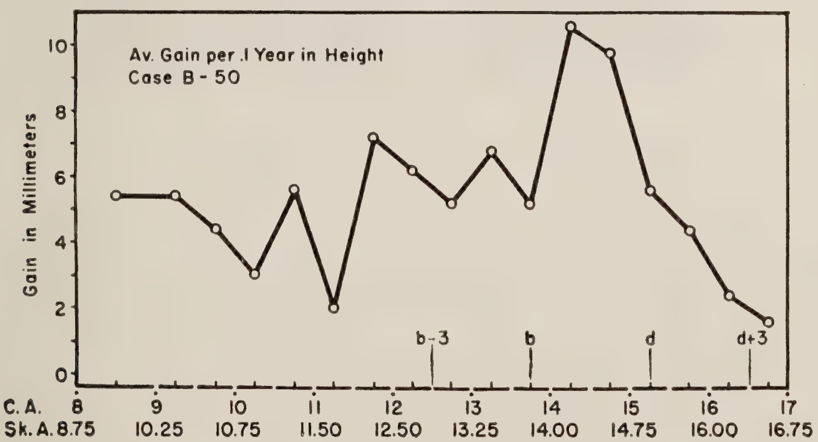
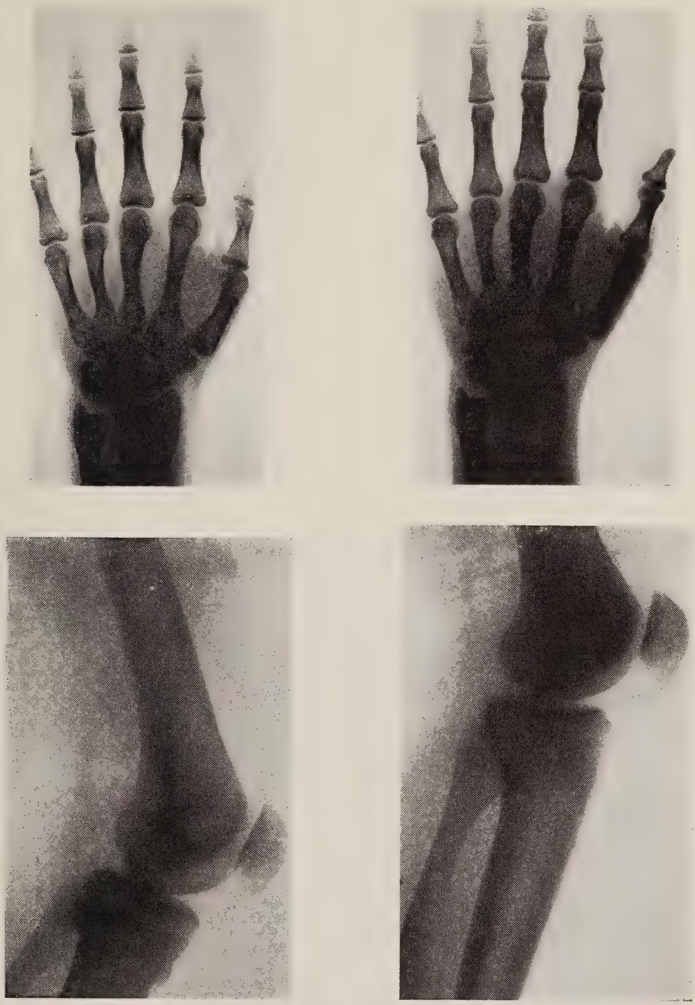


FIGURE 132a. This figure shows the height growth profile for Case B50, whose X-ray photographs appear in Figure 132b, and indicates the relation between skeletal age and chronological age at the developmental points for height.

Case B15

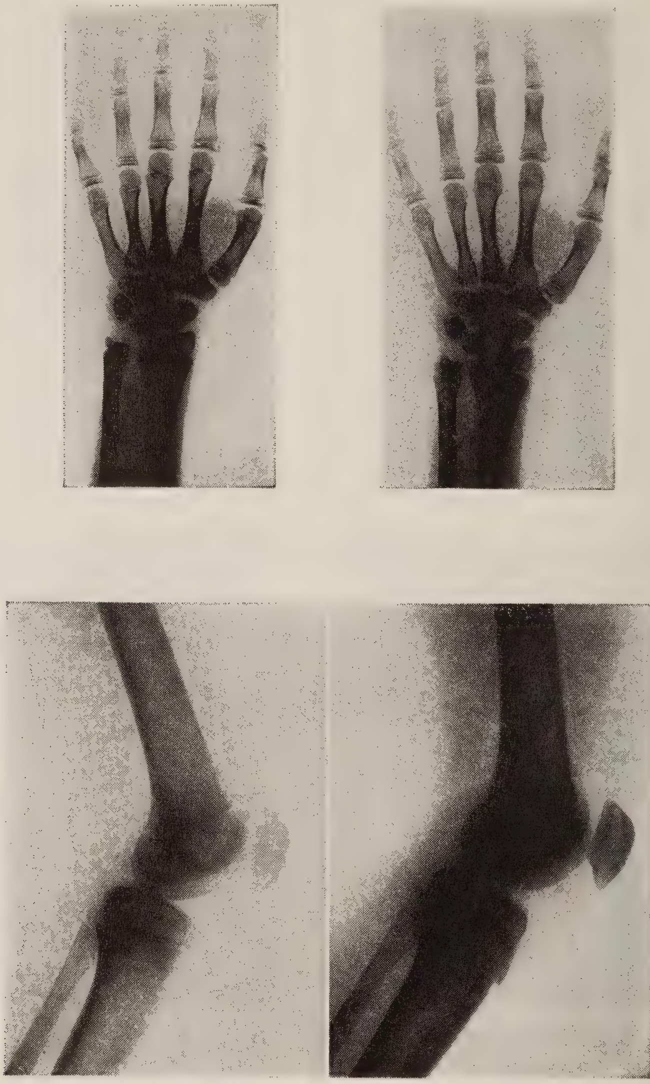
	Prepuberal	Puberal onset
Sk.A.	11.75	12.75
C.A.	11.00	12.25

FIGURE 131b.



Puberal end		Postpuberal	
Sk.A.	15.50	Sk.A.	16.75
C.A.	14.75	C.A.	16.00

FIGURE 131b. The X-ray photographs reproduced in this figure show the hand and knee ossification development of a boy (Case B15) at four points in his height development. The skeletal ages given refer to both photographs directly above them. At three of the four developmental points for height growth (Points b — 3, d, d + 3) this boy's skeletal age is at the mean for the group; at the fourth point (b) his skeletal age is .25 year below the group mean. Approximately 75 per cent of the cases studied showed a consistently close correspondence between general skeletal development and height development.



Case B50

	Prepuberal	Puberal onset
Sk.A.	13.00	13.75
C.A.	12.50	13.75

FIGURE 132b

	Puberal end	Postpuberal
Sk.A.	15.25	16.25
C.A.	15.25	16.50

FIGURE 132b. The arrangement of this figure is similar to Figure 131b. The X-ray photographs show hand and knee ossification of a boy (Case B50) at Points b — 3, b, d, and d + 3 in height development. At Point b — 3 his skeletal age was 1.25 years greater than the mean for this point in height development; at Point b it was advanced .75 year; at Point d it had close correspondence with the mean for skeletal development, lagging only .25 year; at Point d + 3 skeletal development was .50 year below the mean. This case is one of the 25 per cent in which the correspondence shown between height development and general skeletal development varied significantly during the adolescent period.

SUMMARY

Skeletal age ratings were available for 21 boys at the onset of the puberal period for height, for 48 boys at the mid-point of the period, and for 86 boys at the end of the period. There was a range in skeletal age of the boys at each of these developmental points, but the range was approximately half as great as for chronological age. For 75 per cent of the cases there was close correspondence between height development and skeletal development at these points. This finding supports the conclusions of other studies that skeletal age is a more reliable indicator of somatic maturity than is chronological age.

FOOTNOTES FOR CHAPTER IX

[1] All data relating to skeletal age have been supplied through the courtesy of Dr. Nancy Bayley, Institute of Child Welfare, University of California.

[2] Complete data upon which this chapter is based will be found in Appendix P.

[3] Todd, T. Wingate: *Atlas of Skeletal Maturation.* The C. V. Mosby Company, Medical Publishers, St. Louis, 1937. Also "The Roentgenographic Appraisement of Skeletal Differentiation." *Child Development,* **1**:298–310, 1930.

[4] Bayley, Nancy: "Skeletal Maturing in Adolescence as a Basis for Determining Percentage of Completed Growth." *Child Development,* **14**:1–46; 47–90.

[5] A clinical appraisal of the height curve of Case B 50 would probably locate b at 12.75 years rather than at 13.75 years. It may be questioned whether the statistical formula for locating point b is valid with some growth curves showing a secondary peak in height close to the apex as in Case B 50.

Chapter X CHANGES IN THICKNESS OF SUBCUTANEOUS TISSUE DURING ADOLESCENCE

AMONG the data collected from seriatim examinations of our adolescent boys, there were measurements of the thickness of the subcutaneous tissue layer at three points on the body surface. The photographic records show not only obvious differences in degree of "fatness" among these individuals but also, in some individuals, striking change during the maturing process. It seems useful, therefore, to present an analysis of these measurements with a view to determining the relation of their pattern to other patterns of change during the adolescent period.

The measurements of subcutaneous tissue were made with the spring calipers devised by Franzen and his coworkers. The technique is described on page 27. The tissue was measured over the left biceps, beside the umbilicus, and at the left iliac crest. Since the calipers measure a fold of tissue, the measurements recorded in millimeters are taken as twice the actual thickness. For the purposes of this analysis the sum of the three measurements is taken as representing an index of subcutaneous tissue thickness for the individual at the time of measurement.

SUBCUTANEOUS TISSUE INDEX AT SIX DETERMINATIONS

In making a statistical analysis of the group data, six determinations of the subcutaneous tissue index were used. These determinations were taken at (1) the first examination, (2) the third examination before the onset of the puberal period for height (b — 3), (3) the onset of the puberal period (b), (4) the end of the puberal period (d), (5) the third examination following the end of the puberal period (d + 3), and (6) the last examination given.[1]

We are convinced that the data from the first examination and the last examination are pertinent and sometimes particularly illuminating and, therefore, we have included them. However, the time span between the first examination and the onset of the puberal period for height growth varies from .5 year to 3.5 years, and that between the end of the puberal period

mm	Case numbers
28	60, 34
30	30
32	190, 100, 80, 68, 62
34	*178*, *142*, 168, 136, 84, 52, 10
36	*140*, *6*, 206, 154, 130, 116, 92, 26, 8, 230, 220, 112, 96, 72, 18
38	236, 166, 64, 40
40	*90*, *4*, 50, 244, 184, 180, 144, 44
42	*296*, *158*, *170*, 292, 86, 78, 24, 212, 176, 106
44	294, 242, 234, 134, 304, 218, 110, 32
46	
48	*228*, 150, 108, 164, 88
50	
52	58
54	*12*, 120
56	*162*, 216
58	54, 104, 36
60	*118*, 82
62	
64	
66	224, 146, 66, 250
68	
70	
72	74
74	
76	
78	
80	
82	

FIGURE 133a. Distribution of 80 boys by case numbers according to subcutaneous tissue index at first examination. For intensive sample of 67 boys: mean, 42.99 millimeters; standard deviation, 11.55 millimeters; median, 40.80 millimeters; Q_1, 36.62 millimeters; Q_3, 45.81 millimeters. Supplementary cases (13) in italics.

mm	Case numbers
28	60
30	
32	80, 62
34	34, 168, 100, 92, 10
36	*142*, *140*, 116, 26, 8, 220, 206, 190, 180, 96, 72, 18
38	*296*, *178*, 184, 176, 68, 64
40	*4*, 230, 166, 144, 136, 44, 40
42	*228*, *170*, *158*, 292, 244, 112, 86, 78, 234, 30
44	294, 242, 52, 304, 134, 108, 32
46	*6*, 130, 50, 154, 110
48	218, 150, 106, 84, 164
50	212
52	
54	*90*, 120
56	216, 24
58	54, 104, 36
60	*118*, 82
62	88, 236
64	*12*
66	146, 250, 58
68	
70	
72	74
74	*162*
76	
78	66
80	
82	224

FIGURE 133b. Distribution of 80 boys by case numbers according to subcutaneous tissue index at third examination before onset puberal growth period. For intensive sample of 67 boys: mean, 45.39 millimeters; standard deviation, 11.41 millimeters; median, 43.70 millimeters; Q_1, 37.58 millimeters; Q_3, 49.81 millimeters. Supplementary cases (13) in italics.

mm	Case numbers
34	*140*, 190
36	116, 96, 68, 40, 26, 206, 168
38	*142*, 72, 60, 230, 176, 112
40	*296*, *178*, *4*, 220, 134, 100, 62, 52, 34
42	*228*, 236, 294, 166, 154, 136, 92, 80
44	*158*, 144, 244, 180, 130, 110, 108, 32
46	*170*, *6*, 150, 78, 30, 8, 106, 86
48	10
50	304, 50, 18, 292, 212
52	224, 184, 44, 242, 64
54	54
56	234, 218, 84, 120, 24
58	*90*, 164, 104
60	
62	
64	*12*, 146, 58, 88
66	36, 216
68	250
70	82
72	*162*, 74
74	
76	
78	
80	*118*
82	
84	
86	
88	66

FIGURE 133c. Distribution of 80 boys by case numbers according to subcutaneous tissue index at onset of puberal growth period. For intensive sample of 67 boys: mean, 48.33 millimeters; standard deviation, 10.56 millimeters; median, 46.50 millimeters; Q_1, 40.94 millimeters; Q_3, 54.25 millimeters. Supplementary cases (13) in italics.

					302																	
					172	*4*																
					170	234																
					6	144	*300*															
					180	64	*42*															
			140	*232*	250	8	304															
			190	*56*	206	292	294		*114*													
			168	230	106	220	184		242													
			112	176	50	154	164		166													
			92	40	34	150	104	*14*	120													
			68	24	130	110	30	*2*	88													
			32	236	116	72	74	80	84													
		60	136	100	78	62	54	244	224	*118*				218								
	96	134	44	52	26	10	18	108	212	*102*	*58*		216	86		36		82		146	162	66
mm	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	88

FIGURE 133d. Distribution of 83 boys by case numbers according to subcutaneous tissue index at end of puberal growth period. For intensive sample of 67 boys: mean, 44.99 millimeters; standard deviation, 9.08 millimeters; median, 42.43 millimeters; Q_1, 39.44 millimeters; Q_3, 46.13 millimeters. Supplementary cases (16) in italics.

									42																			
									6																			
							232		*2*																			
							114	*300*	304																			
							180	*172*	166																			
						140	154	*4*	106																			
						56	112	206	100																			
						250	110	108	80		224																	
						136	72	68	78		104																	
						130	62	52	54		294		212															
					170	32	190	34	230		242		116		216													
					220	144	184	30	86	*102*	234	*118*	164		88													
			302		176	44	134	24	64	236	146	120	150		84	*14*		218										
		60	96		168	26	92	10	8	40	50	58	18	292	74	244		36	82			66	*162*					
mm	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82

FIGURE 133e. Distribution of 83 boys by case numbers according to subcutaneous tissue index at the third examination following end of puberal growth period. For intensive sample of 67 boys: mean, 45.91 millimeters; standard deviation, 7.61 millimeters; median, 44.88 millimeters; Q_1, 41.12 millimeters; Q_3, 51.12 millimeters. Supplementary cases (16) in italics.

					172																						
					170																						
				114	*6*																						
			302	250	*2*																						
			56	206	292																						
			4	112	166																						
			180	106	154																						
			96	68	120					*42*																	
		136	62	52	78	*232*	224			150																	
		130	190	34	230	*102*	116			304																	
	140	100	184	30	176	86	74		*300*	242				218													
	60	80	168	24	108	72	294		212	164				88													
	220	26	134	10	64	32	234	*118*	110	104	*14*			36													
	92	44	54	144	40	236	50	146	8	58	84	244	82	18				216	*162*								66
mm	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88

FIGURE 133f. Distribution of 83 boys by case numbers according to subcutaneous tissue index at the final examination. For intensive sample of 67 boys: mean, 47.45 millimeters; standard deviation, 8.96 millimeters; median, 45.20 millimeters; Q_1, 41.92 millimeters; Q_3, 52.63 millimeters. Supplementary cases (16) in italics.

and the last examination is also from .5 year to 3.5 years. Therefore the first and last examinations are not strictly comparable points, in either time or development, for the 67 cases.

The results of this statistical analysis of the group data are given in Table 62 and the distribution of the cases in Figures 133a, b, c, d, e, and f.

The significance of the difference of the subcutaneous tissue index between each two consecutive determinations was computed. All were significant at the .001 level except two. Between b — 3 and b the critical ratio was 2.93 which is significant if a criterion of two out of a thousand is used; between d and d + 3 the critical ratio was 2.21 which is significant only if the criterion is lowered to one out of a hundred. (See Appendix X.)

Table 62 CHANGES IN AMOUNT OF SUBCUTANEOUS TISSUE IN RELATION TO THE PUBERAL GROWTH PERIOD FOR HEIGHT—67 BOYS

Rating in Millimeters	*First Examination**	*Third Examination before Onset Puberal Growth Period†*	*Onset Puberal Growth Period*	*End Puberal Growth Period*	*Third Examination Following End Puberal Growth Period‡*	*Last Examination**
Range	29–72	29–82	35–88	33–89	31–70	36–88
Mean	42.99	45.39	48.33	44.99	45.91	47.45
Standard deviation	11.55	11.41	10.56	9.08	7.61	8.96
Median	40.80	43.70	46.50	42.43	44.88	45.20
Q_1	36.62	37.58	40.94	39.44	41.12	41.92
Q_3	45.81	49.81	54.25	46.13	51.12	52.63
Quartile range	9.19	12.23	13.31	6.69	10.00	10.71
Lower quartile range	4.18	6.12	5.56	2.99	3.76	3.28
Upper quartile range	5.01	6.11	7.75	3.70	6.24	7.43

* First examination varied from one examination to nine examinations before onset puberal growth period; last examination varied from one examination to eight examinations after end puberal growth period of height.

† Rating was taken at third examination (approximately 1.5 years) preceding the onset in 54 cases, at second examination in 9 cases, and at first examination preceding the onset in 4 cases.

‡ Rating was taken at third examination following the end of the puberal growth period in 52 cases, at second examination in 11 cases, and at first examination following the end in 4 cases.

From this table and these figures it is clear that there was a wide range among the cases as to amount of subcutaneous tissue at each of the six determinations. At each point the boy with the thickest layer of subcutaneous tissue had about two and a half times as much as the boy with the least. Thus, the sample included boys who by measurement, as well as by appearance, may be called fat, boys who may be called thin, and boys who represent gradations between these two types. Figure 134 shows the curves of three boys (Cases 60, 82, and 304) selected as relatively low, average, and high in subcutaneous tissue throughout.

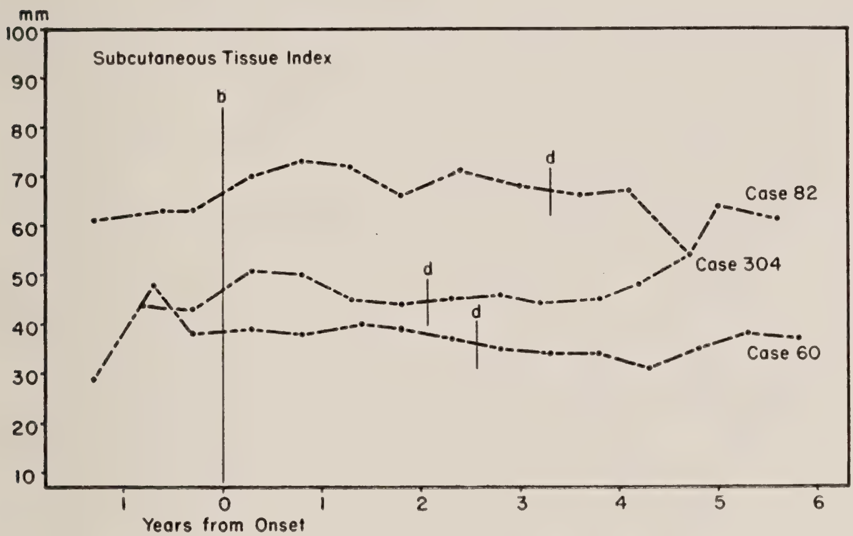


FIGURE 134. Curves of subcutaneous tissue index for three boys each of whom kept a consistent relation to the group in amount of subcutaneous tissue: Case 60 relatively low, Case 304 about average, Case 82 relatively high.

It will be noted that the distribution of the 67 cases at the first examination is distinctly unsymmetrical, with what appears to be a tendency to bimodality (Figure 133a). This asymmetry persists through the distributions for subsequent determinations, but the bimodal tendency becomes progressively less distinct. To test the suspicion that this skewness might be due to insufficient number of cases, we added measurements from 22 other cases which gave reliable and valid data for these particular distributions, but which were not included in our 67 sample for various reasons. This addition increased by 13 the cases in the first three distributions and by 16 the cases in the last three distributions. These additional cases are printed in italics in the tables.[2] It will be seen that they fall so as to reinforce the skewed pattern already sketched by the main sample, and thus

they weaken the suspicion that the skewness is due merely to an insufficient number of cases. Later analysis showed that 12 of the 15 cases which seem to cluster about a secondary mode in Figure 133a, and which tend to straggle far to the right of the main group in the succeeding distributions, were boys who experienced a marked fat period during early adolescence.[3] The other three passed through a definite, though less marked, fat period.

THE CONSISTENCY OF THE SUBCUTANEOUS TISSUE INDEX

Earlier in this chapter we drew attention to the tendency of certain cases to remain in the same relation to the group in each of the six distributions. In order to find out to what degree this tendency to remain in the same quartile position held for the other cases, we tabulated the quartile positions for all 67 cases at each of the six distributions.

The data obtained has been summarized as follows:

Of the 67 cases, for six determinations:

40 (59.70 per cent) held the same quartile position at b — 3 as at the first examination.
32 (47.76 per cent) held the same quartile position at the puberal onset (b) as at b — 3.
35 (52.24 per cent) held the same quartile position at the end of the puberal period (d) as at the onset (b).
34 (50.74 per cent) held the same quartile position at d + 3 as at d.
43 (64.18 per cent) held the same quartile position at the final examination as at d + 3.

Of the 67 cases, for the determinations at b — 3, b, d, and d + 3:

12 (17.90 per cent) held the same quartile position at each of the four determinations.
32 (47.76 per cent) were in one of two adjacent quartiles at each of the four determinations.
15 (22.39 per cent) were in one of three adjacent quartiles at each of the four determinations.
4 (5.97 per cent) appeared in all four quartiles.
2 (2.98 per cent) appeared in two nonadjacent quartiles.
2 (2.98 per cent) appeared in three quartiles, one of which was nonadjacent to the other two.

Thus, there was considerable variation among our 67 cases as to consistency of quartile position, with two thirds of the cases showing a definite tendency toward relative positional consistency, while the other third moved through at least three quartiles in the course of the four central determinations.

The curves of Cases 60 and 82, presented in Figure 134, page 257, were consistently in the first and fourth quartile, respectively, throughout.

Figure 135a contrasts the curves of two boys (Cases 236 and 34), one of whom (Case 236) had relatively great inconsistency in amount of subcutaneous tissue and one of whom (Case 34) had relatively small changes. Figure 135b shows the photographs of these two boys.

DEVELOPMENTAL RHYTHM IN SUBCUTANEOUS TISSUE VARIATIONS

The most interesting and probably the most significant of our findings concerning the variations in thickness of subcutaneous tissue in boys during the adolescent period is the strong tendency toward a definite pattern of increase and decrease which appears to be connected with successive stages in development. As may be seen in Table 62, the mean index for the group increased from the first to the second and from the second to the third determination, decreased from the third to the fourth, and then increased from the fourth to the fifth, and from the fifth to the sixth. The same general pattern is shown by the median values and by those for Q_1 and Q_3.

Even before the subcutaneous tissue measures for the group had been analyzed, we were convinced from the photographic series that at least 25 per cent of our boys showed an obvious increase in subcutaneous tissue during the prepuberal period. The statistical analysis indicated that the occurrence of this phenomenon was even more frequent, there being an increase in 52 of the 67 cases, or 77.61 per cent. We had also noticed that the photographs quite frequently showed an obvious decrease in plumpness during the puberal period. The measurements at Points b and d showed that this was true in some degree for 44 of 67 boys, or 65.67 per cent. The

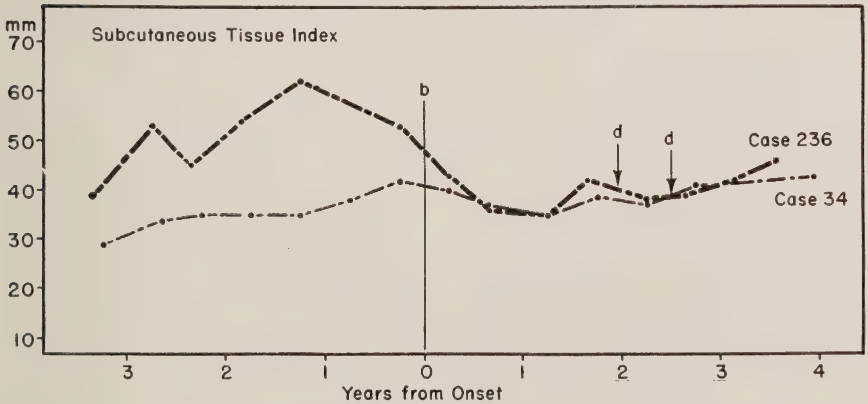
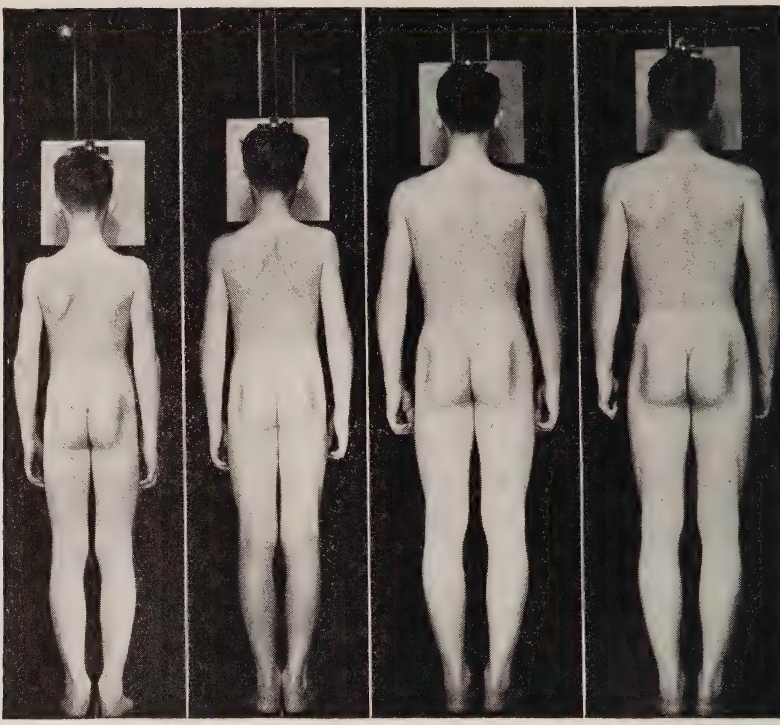


FIGURE 135a. Contrasting curves of subcutaneous tissue index for two boys. Case 34 had relatively small changes throughout, while Case 236 had dramatic changes during the prepuberal period. Case 34 had a mild, while Case 236 had a marked fat period in early adolescence. (See Chapter XV.) Photographs in Figure 135b.



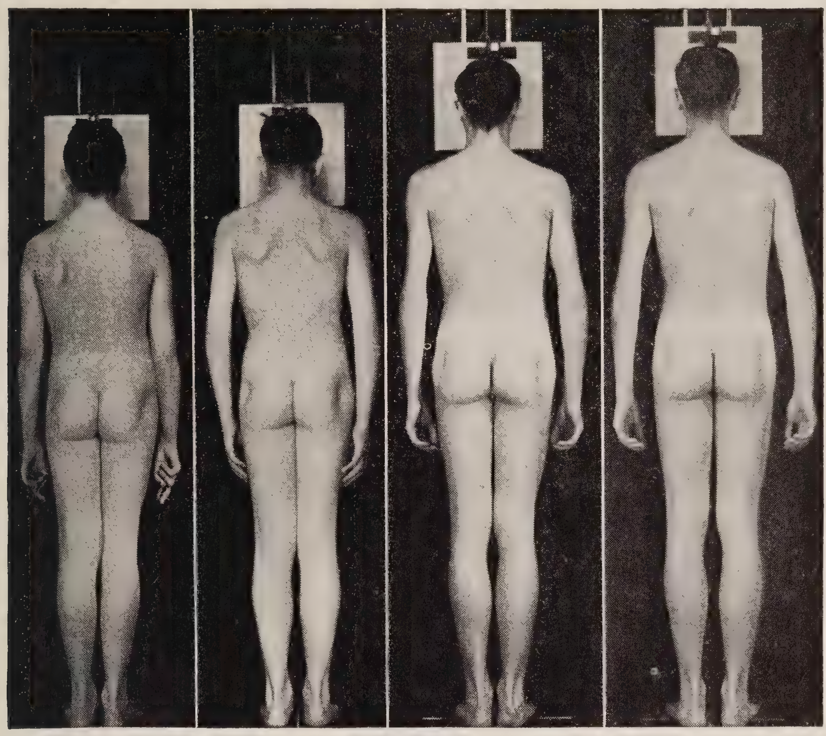
Case 34

C.A. 12.9	14.1	16.6	18.1
Prepuberal	Puberal onset	Puberal end	Postpuberal

FIGURE 135b.

increase during the postpuberal period which occurred in 49 of 66 cases [4] (74.2 per cent) was not usually so striking in the photographs but was quite obvious in a considerable number. A summary of these data is presented in Table 63.[5]

The percentages for the pattern of prepuberal increase, puberal decrease, and postpuberal increase were sufficiently large to determine the complete pattern for the group. When we analyzed the changes which occurred within each individual, using Points b — 3, b, d, and d + 3 as the points of measurement, the percentage of cases which displayed the common pattern was not so great. The several patterns found with the number of cases which showed each pattern are summarized in Table 64. There were 43.28 per cent of the 67 cases which showed the complete pattern. Over half of the cases (55.22 per cent) showed the prepuberal-increase, puberal-decrease pattern, but among the remainder there were several variations in the rhythm of subcutaneous tissue increase and decrease. The discrepancies between individual patterns of subcutaneous tissue change and the



Case 236

C.A. 12.7	13.9	15.9	17.5
Prepuberal	Puberal onset	Puberal end	Postpuberal

FIGURE 135b. Photographs of the two boys (Cases 34 and 236) whose curves of subcutaneous tissue index are shown in Figure 135a. Photographs were taken three examinations before onset, at onset, at end, and three examinations after end of puberal growth period.

pattern for the group may have been due in part to transitory factors of health, nutrition, exercise, or emotional problems for the analysis of which our data are not adequate.

If, however, instead of comparing the measurements taken at the specific points b — 3, b, d, and d + 3, we scan the individual profiles for the seven year period and note the positions of the principal flexions, we find a much higher percentage of cases which displayed the total pattern. About two thirds (66.15 per cent) of the 65 cases which had adequate data for this analysis showed the rhythm of rise from a prepuberal low to an apex, followed by a decrease and final postpuberal rise. All of the cases had the initial low point during the prepuberal period, at the first or second examination in the series. The apex was more variable in its occurrence, though there was a definite relation to the onset of puberal height growth (b).

Table 63 CHANGES IN SUBCUTANEOUS TISSUE INDEX—67 BOYS

	Cases		*Range of Change*	*Average Change*
	Number	Per Cent	Millimeters	Millimeters
From first examination to b				
Increase	52	77.61	1–21	7.81
Same	5	7.46		
Decrease	10	14.92	1–14	4.20
From third examination before onset to b				
Increase	39	58.21	1–15	5.46
Same	7	10.45		
Decrease	21	31.34	1–29	4.67
From b to d				
Increase	21	31.34	1–13	3.00
Same	2	2.98		
Decrease	44	65.67	1–29	7.84
From d to third examination after d				
Increase	40	59.70	1–15	5.45
Same	5	7.46		
Decrease	21	31.34	1–22	4.13
No data	1	1.49		
From d to last examination				
Increase	49	73.13	1–19	5.71
Same	1	1.49		
Decrease	16	23.88	1–20	4.53
No data	1	1.49		

Of the 42 boys who showed the common pattern, 35 had the apex within .75 year of the onset. Of the remaining 7 cases, the apex of subcutaneous tissue occurred at 2.25 years before b for one, at 1.25 years before b for one, at 1.25 years after b for 3, at 1.75 years after b for one, and at 2.25 years after b for one. Of these seven cases those who experienced a marked increase in fatty tissue *during the puberal period* showed greater emotional disturbance.

Just as the apex of subcutaneous tissue growth bore a close timing relation to the onset of the puberal period for height, so the low point following this apex was closely related in timing to the end of the puberal period of height growth. Out of the 42 cases 31 (73.81 per cent) had this low point within .75 year of d; the remaining 11 cases occurring as follows: 4 at d — 3, 3 at d + 3, 2 at d + 4, and 2 at d + 5. The final rise occurred for all cases in the postpuberal period.

Table 64 PATTERNS OF CHANGE IN SUBCUTANEOUS TISSUE INDEX—67 BOYS

Pattern	*Cases*		*Changes in Amount Subcutaneous Tissue*		
	Number	Per Cent	Prepuberal Period	Puberal Period	Postpuberal Period
A	29	43.28	+	−	+
B	6	11.94	+	−	−
	1		+	−	0
	1		+	−	?
C	7	13.43	+	+	+
	2		+	0	+
D	3	8.95	−	−	+
	3		0	−	+
E	6	8.95	+	+	−
F	4	11.94	−	+	+
	1		0	+	+
G	2		−	+	−
	1		0	+	−
H	1		−	−	−

+ increase; − decrease; 0 no change; ? no data.

TIMING OF THE APEX GROWTH FOR SUBCUTANEOUS TISSUE IN RELATION TO THE PUBERAL PERIOD

The largest increment in growth of subcutaneous tissue among 65 boys was made by 21 (32.31 per cent) during the prepuberal period, by 18 (27.69 per cent) during the puberal period, and by 26 (40.00 per cent) during the postpuberal period. There was only one case (Case 34) which had synchrony of height apex and subcutaneous tissue apex.[6] The others were about equally divided, 45.45 per cent preceding height apex and 51.51 per cent following height.[7]

SUMMARY

Analysis was made of the subcutaneous tissue measurements of the 67 boys at six determinations. These included the first and last examination in addition to the four developmental points related to the puberal period.

There was a wide range in amount of subcutaneous tissue among the cases at each determination. At each point the "fattest" boy had an index two and a half times as great as the "thinnest" boy. There was a tendency toward bimodality in the distribution which persisted, though less markedly with increasing maturity. The extreme cases which clustered about the

second mode were for the most part boys who experienced an early adolescent fat period.

There was considerable variation in the position which a boy held among the group at the several determinations. About two thirds of the cases held the same quartile position or stayed within two adjoining quartiles.

Although each boy's curve in changes in subcutaneous tissue was unique, there was a distinct tendency for a definite rhythm of increase and decrease. The rhythm followed the pattern of an initial low point during the prepuberal period, followed by a rise to an apex within about nine months of the puberal onset. From this apex the curve decelerated to another low point within about nine months of the end of the puberal period, from which there followed a rise in the postpuberal period.

The apex of subcutaneous tissue increase occurred with greatest frequency following the puberal period, with next greatest frequency preceding the puberal period, and with least frequency during the period. The cases were about equally divided in having the subcutaneous tissue apex before or after height growth apex. In only one case was there synchrony with the height apex.

FOOTNOTES FOR CHAPTER X

[1] Complete data on subcutaneous tissue index for 67 boys will be found in Appendix Q.

[2] Of the 22 added cases, 6 provided data for all six points; 7 for the first three points only; 9 for the last three points only.

[3] Cases 58, 12, 162, 216, 36, 118, 82, 224, 146, 66, 250, and 74. See discussion of early adolescent fat period in Chapter XV.

[4] There were no postpuberal data for Case 130.

[5] Complete data for 67 boys will be found in Appendix Q.

[6] Case 34 had two other equally large apexes in subcutaneous tissue, one in the prepuberal period and one in the postpuberal period.

[7] One case (Case 112) had one apex of subcutaneous tissue before and one apex after height apex.

Chapter XI GROWTH IN THIGH CIRCUMFERENCE DURING ADOLESCENCE

OF the several circumference measurements taken routinely for each boy at each examination, there were three which may be used to study the increases in limb circumferences. One of these was the circumference of the upper left arm, one of the left thigh, and one of the left calf.[1]

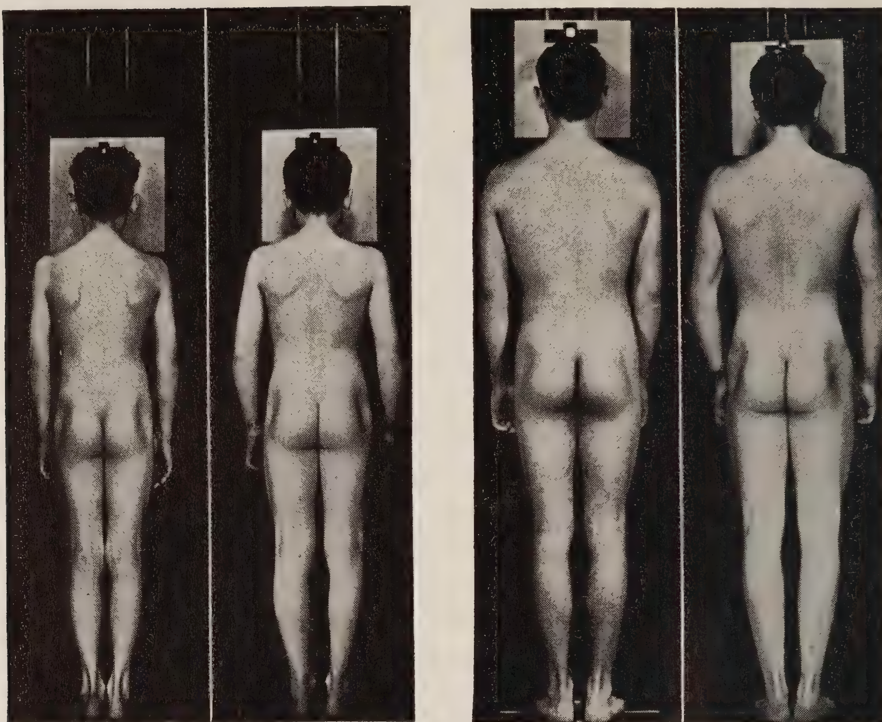
These measurements give us information concerning the combined growth of soft tissues, including chiefly muscle thickness, amount of interstitial fat, and amount of subcutaneous tissue. It is true that they also include growth of bony tissue, vascular tissue, and nervous tissue, but these constitute a relatively small proportion of the whole.

We are confining our presentation of data concerning growth in limb circumferences to those for the thigh. The timing of the increases and decreases in arm circumference and calf circumference show a high degree of correspondence with the timing for thigh circumference.[2] Thigh circumference includes the largest mass of muscular tissue that can be measured and therefore gives the best promise of data which may be used as an index of the cross-sectional growth of muscle tissue throughout the body during the adolescent period. The two boys shown in Figure 136 illustrate the changes in thigh circumference which take place during adolescence.

MEASUREMENTS OF THIGH CIRCUMFERENCE

The thigh circumference measurements for our 67 boys, at the third examination before the onset of the puberal growth period for height (b — 3), at the onset of that period (b), at the end of that period (d), and at the third examination after the end of that period (d + 3) are summarized in Table 65.[3] The critical ratios of the difference of the measurements of the boys between each two consecutive developmental points were significant. (See Appendix X.)

The mean circumference increased steadily from the prepuberal period, 421.15 millimeters (16.58 inches) to the postpuberal period, 508.74 millimeters (20.03 inches). There was wide overlapping at each point with the measurements at the points preceding and following. The largest thigh



	Case 62	Case 304	Case 62	Case 304
C.A.	12.2	12.3	17.3	16.3
	Prepuberal		Postpuberal	

FIGURE 136. These two boys, who were both relatively short, both muscular, and who commenced their puberal period for height within the same three months, illustrate persistent difference in thigh circumference. In these two cases subcutaneous tissue was a relatively unimportant factor in determining the size of the measurements.

circumference in the prepuberal period was 135 millimeters (5.32 inches) greater than the smallest thigh circumference in the postpuberal period.

The range of difference between the boy with the smallest thigh circumference and the boy with the largest decreased steadily from the point in the prepuberal period (b — 3) to the point in the postpuberal period (d + 3). The standard deviation from the mean decreased from 41.00 millimeters in the prepuberal period to 32.06 millimeters in the postpuberal period, while the actual measurements were increasing. The coefficients of variability in Table 66 show how much greater this decrease in variability was from the prepuberal to the onset of the puberal period (b — 3 to b) than it was from the close of the puberal period to the postpuberal period

Table 65 CHANGES IN THIGH CIRCUMFERENCE IN RELATION TO PUBERAL GROWTH PERIOD FOR HEIGHT—67 BOYS

A. MILLIMETERS

	Range	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3
Prepuberal (b − 3)	357–575	421.15	41.00	415.00	396.79	437.08
Onset puberal period (b)	373–584	438.94	38.12	434.37	414.58	457.50
End of puberal period (d)	428–615	498.64	33.90	491.87	468.86	515.62
Postpuberal (d + 3)	440–598	508.74	32.06	510.00	485.62	533.57
Gain onset to end (b to d)	6–106	56.94	24.20	60.83	41.96	75.42

B. INCHES

	Range	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3
Prepuberal (b − 3)	14.06–22.64	16.58	1.64	16.34	15.62	17.21
Onset puberal period (b)	14.69–22.94	17.28	1.50	17.10	16.32	18.02
End of puberal period (d)	16.84–24.22	19.62	1.33	19.36	18.45	20.30
Postpuberal (d + 3)	17.32–23.54	20.03	1.26	20.08	19.12	21.01
Gain onset to end (b to d)	.24– 4.17	2.24	.89	2.39	1.65	2.97

Table 66 VARIABILITY IN THIGH CIRCUMFERENCE MEASUREMENTS COMPARED WITH OTHER MEASUREMENTS—67 BOYS

	Coefficient of Variability		
Measurement Point	*Thigh*	*Subcutaneous Tissue*	*Height*
b − 3	9.74	26.07	4.30
b	8.65	21.85	4.02
d	6.76	20.40	3.83
d + 3	6.30	16.58	3.65

(d to d + 3). Although variability was much less for thigh than for subcutaneous tissue, it was considerably greater than for height at all four points.

The distributions of our cases according to magnitude of thigh circumference at b — 3, b, d, and d + 3 are shown in Figures 137a, b, c, and d.

							244															
							184															
							34															
							78															
							24															
							130															
							154															
							112															
					26	116	68															
				60	242	86	50		58													
				220	176	144	40	168	292	120												
				32	206	108	8	106	294	218			250									
				96	30	72	212	52	54	88			104									
	100	62	80	84	134	166	64	44	164	150			216									
	92	180	190	230	234	136	10	18	110	304	82		146	36		236		74		66			224
mm	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570

FIGURE 137a. Distribution of 67 cases according to the magnitude of thigh circumference as measured at the third examination before the onset of the puberal growth period for height (b — 3): mean, 421.15 millimeters; standard deviation, 41.00 millimeters; median, 415.00 millimeters; Q_1, 396.79 millimeters; Q , 437.08 millimeters.

						134																
						84																
						78	234															
				136		68	164	150	106													
				60	176	168	58	110	50													
				96	86	166	54	294	304	218												
				80	52	30	64	24	18	292												
			206	242	40	130	144	34	154	146												
	92	62	190	220	72	116	212	244	44	82		104	250		74							
	100	180	230	26	32	108	112	10	8	184	120	88	236		36			224				66
mm	370	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580

FIGURE 137b. Distribution of 67 cases according to the magnitude of thigh circumference at the onset of the puberal growth period for height (b): mean, 438.94 millimeters; standard deviation, 38.12 millimeters; median, 434.37 millimeters; Q_1, 414.58 millimeters; Q_3, 457.50 millimeters.

					206															
					134															
					32	52														
					164	54		116	34											
					136	144		236	80											
					154	112		106	68											
				242	44	108	146	184	244		8									
				190	24	220	26	88	10	304	104	120								
				96	72	230	64	78	58	168	292	218								
				100	62	86	110	40	250	166	150	234	82							
	92		60	180	176	130	30	50	84	212	18	294	36	74	216	224				66
Millimeters	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600	610

FIGURE 137c. Distribution of 67 cases according to the magnitude of thigh circumference at the end of the puberal growth period for height (d): mean, 498.64 millimeters; standard deviation, 33.90 millimeters; median, 491.87 millimeters; Q_1, 468.86 millimeters; Q_3, 515.62 millimeters.

				206												
				100	62	54										
				180	134	52		104	120	292						
				176	108	26		80	116	68						
				154	230	184	250	212	84	294	224					
				96	146	44	34	144	244	304	10					
				190	73	30	40	112	166	236	150	18				
	92			220	164	32	64	110	78	168	82	8				
	60		24	136	242	86	50	106	58	88	234	218	36	216	74	66
Millimeters	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590

FIGURE 137d. Distribution of 66 cases * according to the magnitude of thigh circumference as measured at the third examination after the end of the puberal growth period for height (d + 3): mean, 508.74 millimeters; standard deviation, 32.06 millimeters; median, 510.00 millimeters; Q_1, 485.62 millimeters; Q_3, 533.57 millimeters.

*Data for Case 130 were lacking.

The same case (Case 92) held his relative position at the lower end of the distribution throughout the adolescent period. This was a slender boy who was also the shortest at b — 3 and among the six shortest at d + 3. He had a very thin layer of subcutaneous tissue throughout the adolescent period.

The boy who had the largest thigh circumference at b — 3 in the prepuberal period (Case 224) was at that time exhibiting a marked increase in subcutaneous fat. He ranked second from the upper end of the distribution at b and d, but during the postpuberal period he changed position to just above the third quartile. Case 66, whose thigh circumference was the second largest at b — 3 and largest at b, d, and d + 3, had a thick layer of subcutaneous tissue and bulky muscles. At the beginning of adolescence he was relatively tall, but by the end of the postpuberal period his height was below the mean for the group. These two cases are discussed in more detail in the chapter on increase in adipose tissue during early adolescence (Chapter XV).

PUBERAL GAIN IN THIGH CIRCUMFERENCE

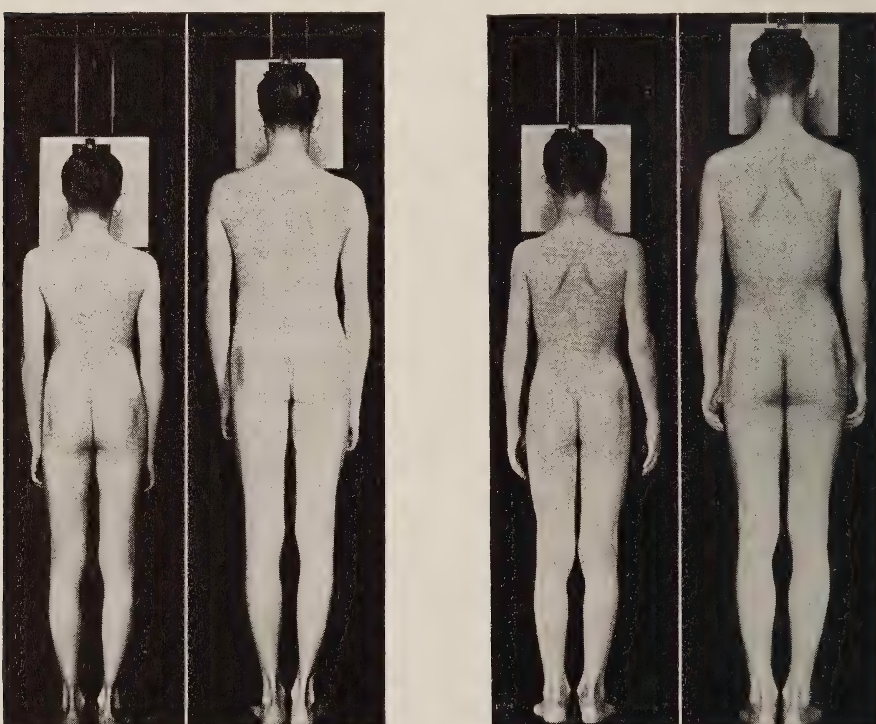
During the puberal period the gains in thigh circumference made by the 67 boys varied from 6 millimeters (.24 inch) to 106 millimeters (4.17 inches), the mean gain being 56.94 millimeters (2.24 inches) (Table 65). The distribution according to amount gained during the puberal period is shown in Figure 138.

In the lower quartile of gains there were fourteen boys who experienced an early adolescent fat period, while in the upper quartile there were only four of these "fat boys." [4] This was due to the fact that the fat period had begun for most of these boys during the prepuberal period, and they had made major gains in subcutaneous tissue before the puberal onset. The loss

of this fat during the puberal period canceled out the gain from muscle growth that took place.

													78								
							74						304								
							144						120	150		82					
							54		108				34	62		68					
					184		134	130	86				244	220		40					
					224		104	92	96	136	190		180	206	230	32		294			
	250		154	24		66	106	110	176	72	292	52	58	218	116	212		168			80
	236	88	44	146	164	36	50	60	112	64	242	30	216	18	8	100	26	166	234	84	10
mm	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105

FIGURE 138. Distribution of 67 cases according to the amount of gain in thigh circumference during the puberal growth period for height (b to d): mean, 56.94 millimeters; standard deviation, 24.20 millimeters; median, 60.83 millimeters; Q_1, 41.96 millimeters; Q_3, 74.42 millimeters.



Case 30 — C.A. 13.7 Puberal onset; 16.7 Puberal end

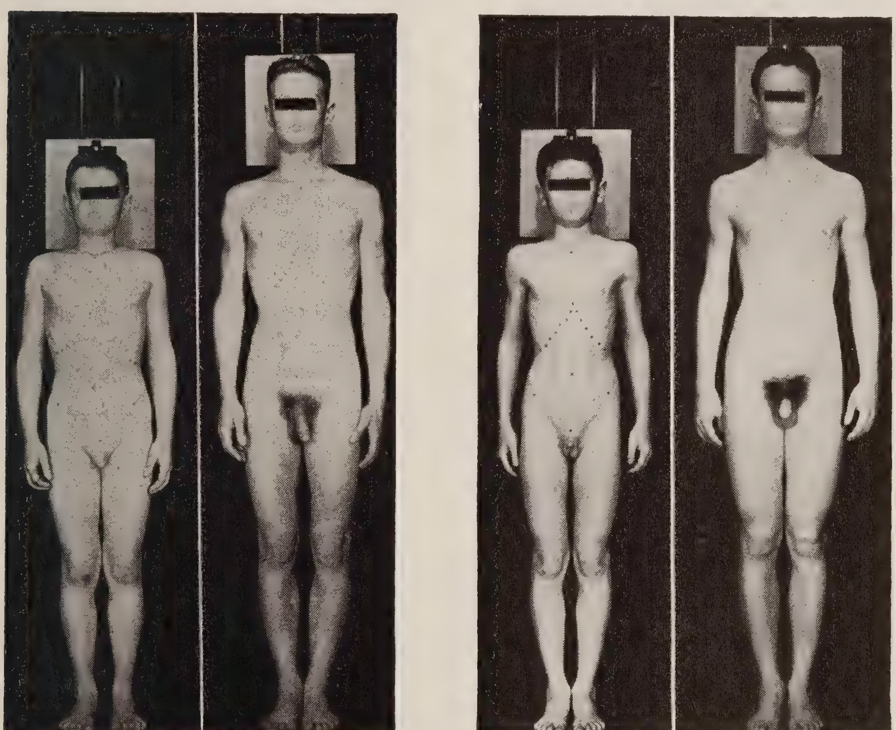
Case 242 — 11.9 Puberal onset; 14.5 Puberal end

FIGURE 139. These two boys (Cases 30 and 242) made average gains in thigh circumference during the puberal period. The puberal duration for Case 30 was 3.50 years; for Case 242 it was 2.65 years.

The two boys in Figure 139 (Cases 30 and 242) are examples of boys who made an average gain in thigh circumference. Figure 140 contrasts two boys (Cases 44 and 80) with different gains, though timing of puberal onset was similar. In Figure 141 are shown photographs of two boys (Cases 60 and 234) who gained very different amounts in thigh circumference in the same time.

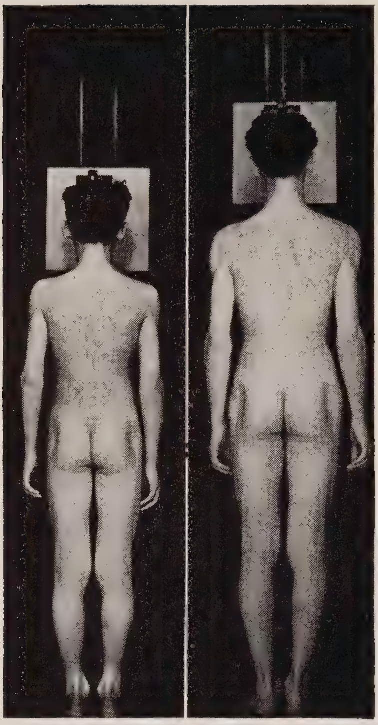
TIMING RELATIONS OF APEX GROWTH FOR THIGH CIRCUMFERENCE

In Table 67 is a summary of the timing relations of the velocity apex of growth in thigh circumference during the adolescent period with reference to the velocity apex of growth for height, stem length, and leg length.



Case 44		Case 80	
C.A. 12.3	14.8	12.3	14.8
Puberal onset	Puberal end	Puberal onset	Puberal end

FIGURE 140. These two boys entered and completed the puberal growth period for height together. During that period (b to d) Case 44 gained 15 millimeters (.59 inch) in thigh circumference, while Case 80 gained 106 millimeters (4.17 inches). The small gain for Case 44 is partly explained by the fact that at b he was passing through a brief but definite phase of increased subcutaneous fat.



Case 60

C.A. 12.3 15.9

Case 234

12.8 16.4

FIGURE 141. These two boys illustrate difference in rate of growth in thigh circumference from the onset to the end of the puberal growth period. In 3.6 years Case 234 increased 113 millimeters (4.45 inches) in thigh circumference; in the same time Case 60 increased 54 millimeters (2.13 inches). In neither case was subcutaneous tissue an important factor in determining the size of the measurements.

Even though the profiles for thigh circumference display high points before and after the puberal growth period for height, 70.15 per cent show the apex occurring during that period (b to d). This is a much lower percentage than for stem length (98.51 per cent), considerably lower than for leg length (86.57 per cent) slightly lower than for shoulder width (76.05 per cent) and for hip width (80.6 per cent).

The apex for thigh circumference growth rarely comes synchronously with leg length, stem length, or height apex. However, it comes within .5 year of leg length apex in over one third of the cases (37.31 per cent) and within .5 year of height apex in slightly more than one third of the cases (34.33 per cent). The interrelations of the timing of stem length and leg length apexes with thigh circumference apex are shown in Table 68. Here again the 67 cases have eight (out of a possible nine) different

sequences in timing. About one third (32.83 per cent) have the thigh circumference apex preceding both stem length and leg length apexes, but about a quarter (26.86 per cent) have it following them.

The relations between thigh circumference growth and leg length growth are of particular interest because they strongly suggest that muscle girth and skeletal length, even in the same limb, develop asynchronously and by different patterns. This is illustrated by the profiles of leg length and thigh circumference shown in Figures 142a, b, c, and d which represent the varying time relations and varying degrees of pattern similarity found in our sample.

Table 67 TIMING RELATIONS OF THE APEX GROWTH FOR THIGH CIRCUMFERENCE—67 BOYS

	Number	*Per Cent*	*Range* Years
Apex within puberal growth period for height	47	70.15	
Apex preceding onset puberal growth period	13	19.40	
Apex following end puberal growth period	7	10.45	
Apex synchronous with leg length apex	9	13.43	
Apex preceding leg length apex	24	35.82	.25–4.65
Apex following leg length apex	34	50.75	.25–5.95
Apex within ±.50 year from leg length apex	25	37.31	
Apex synchronous with stem length apex	10*	14.92	
Apex preceding stem length apex	38	56.72	.45–4.50
Apex following stem length apex	19	28.36	.50–3.65
Apex within ±.50 year from stem length apex	17	25.37	
Apex synchronous with height apex	6†	8.95	
Apex preceding height apex	33	49.25	.45–4.50
Apex following height apex	28	41.79	.50–4.50
Apex within ±.50 year from height apex	23	34.33	

* One also synchronous with leg length apex.
† Four also synchronous with leg length; two with stem length.

CONFIGURATION OF THE GROWTH PROFILE FOR THIGH CIRCUMFERENCE

From an inspection of the curves representing changes in velocity of growth in thigh circumference, it is at once evident that the pattern of change is quite different from that of the length and breadth measures which we have discussed in preceding chapters. For height, stem length, leg length, shoulder breadth, and hip width the characteristic pattern includes a phase of relatively low velocity, followed by a rapid increase to an apex during the puberal period which, in turn, is followed by a marked decrease of velocity during the postpuberal period. The curve representing

Table 68 INTERRELATIONS OF TIMING OF THIGH CIRCUMFERENCE APEX WITH LEG LENGTH APEX AND STEM LENGTH APEX—67 BOYS

		Relation to Leg Length Apex							
		Preceding		Synchronous		Following		Total	
		Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Relation to Stem Length Apex	Preceding	22	32.83	7	10.45	9	13.43	38	56.72
	Synchronous	2	2.98	1	1.49	7	10.45	10	14.92
	Following			1	1.49	18	28.86	19	28.36
Total		24	35.82	9	13.43	34	50.75	67	100.00

velocity changes in thigh growth usually displays several widely separated periods of relatively high velocity. Often these periods alternate with periods of low velocity or even of actual diminution in thigh circumference.

Analyzed for major peaks and major dips by the same technique used for other growth velocity profiles,[5] the thigh circumference profiles show a higher incidence of such peaks and dips than do those for any of the other body dimensions measured. For 67 profiles the mean number of major peaks was 3.67 and the mean number of major dips was 2.47. Figures 142b (Case 8), 142c (Case 84), and 142d (Case 110) show representative individual profiles which indicate the general configurational characteristics.

The magnitude of the changes in growth rate may be, in some instances, due to slight variation in the point and level at which the measurement was taken,[6] but the timing correspondence of the major peaks and dips in these profiles to those for weight and subcutaneous tissue indicates that they represent pretty accurately the changes which took place in the mass of the underlying soft tissues.

The tendency toward parallelism between an individual's growth profiles for thigh circumference and weight is discussed in the chapter on weight.

The marked tendency toward parallelism that was found between the configuration for thigh circumference and that for subcutaneous tissue is illustrated by Case 58 shown in Figure 143. Since this boy passed through a period of fat accumulation which extended through the prepuberal period and into the first half of puberal period, it is not surprising that during that

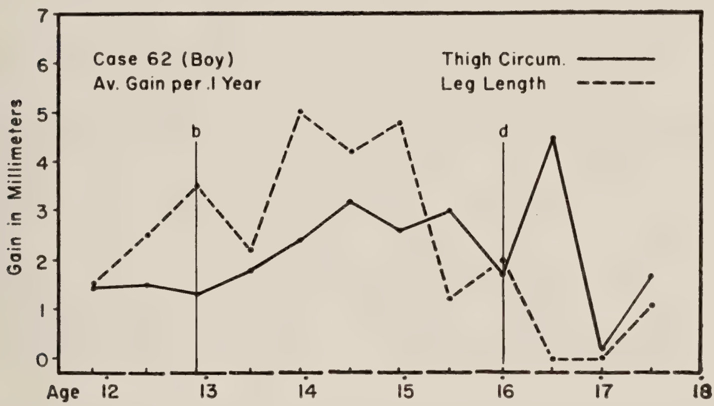


FIGURE 142a. Case 62 illustrates marked similarity of growth profile characteristics, but different timing, between leg length and thigh circumference during the puberal period. During the postpuberal period the growth in thigh circumference spurts markedly, while the corresponding spurt in leg length growth is slight. Note the systematic asynchrony between the corresponding peaks in the two profiles.

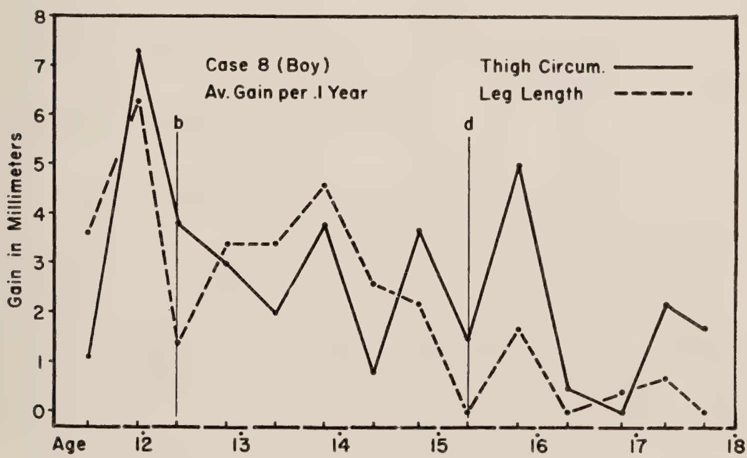


FIGURE 142b. Case 8 illustrates marked difference of growth profile characteristics between leg length and thigh circumference during the puberal period. Synchrony and marked similarity occur in the prepuberal period; synchrony and definite similarity in the postpuberal period.

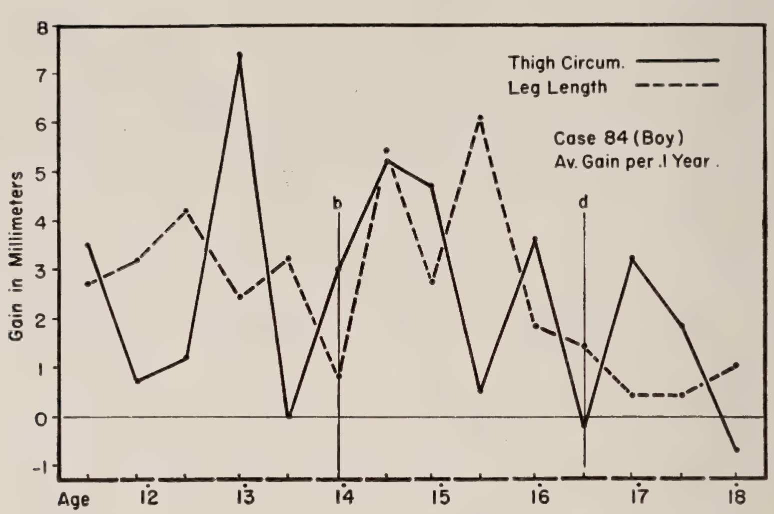


FIGURE 142c. Case 84 illustrates definite similarity with predominant asynchrony in the growth profiles for leg length and thigh circumference during the puberal period. During the prepuberal and also the postpuberal period there is neither synchrony nor similarity between the two profiles.

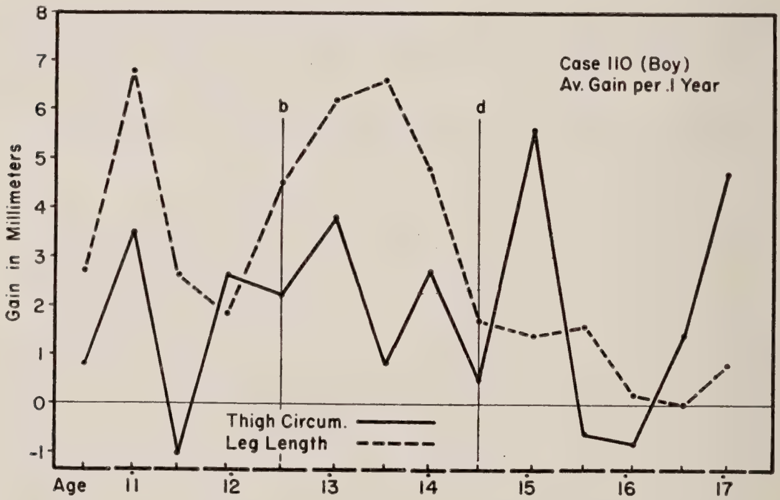


FIGURE 142d. Case 110 illustrates a contrast between the growth profiles for leg length and thigh circumference. At only one point, during the prepuberal period, is there synchrony and similarity. During the postpuberal period there are two separate marked spurts of growth in thigh circumference without any corresponding spurts in leg length.

time the two profiles rose and fell together. But it is interesting that during the last half of the puberal period, when practically none of the marked gain in thigh circumference was due to increase in subcutaneous tissue, the

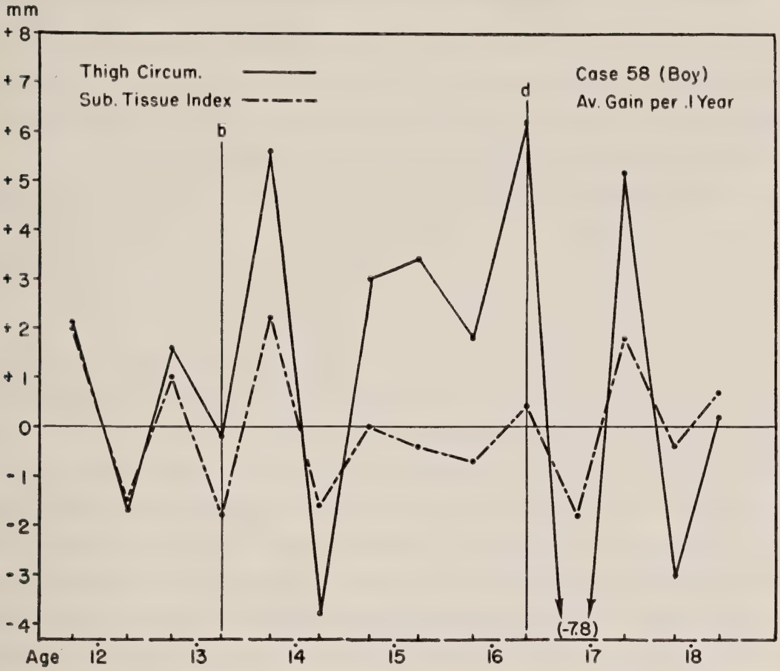


FIGURE 143. These two profiles show the tendency toward parallelism between changes in thigh circumference and in subcutaneous tissue thickness. It will be noted that, except during the last half of the puberal period, gains or losses in thigh circumference were always accompanied by corresponding changes in subcutaneous tissue. The pattern during the exceptional period indicates that at that time the increased growth rate in thigh circumference was due primarily to growth of muscle tissue.

two curves continued to show a marked degree of parallelism. During the postpuberal period subcutaneous tissue thickness again became a significant component of thigh circumference, and so the two configurations peaked and dipped at corresponding times.

SUMMARY

The growth of the 67 boys in thigh circumference was studied as an index of the cross-sectional growth of muscle tissue in the body during adolescence.

The boys differed greatly in thigh circumference at every developmental point, but the differences decreased steadily with maturity. There was overlapping at each point with the measurements preceding and following. Variability for thigh circumference was less than for subcutaneous tissue, but it was considerably greater than for height at all points.

Puberal gains in thigh circumference varied from 6 millimeters to 106 millimeters. Boys who had an early adolescent fat period tended to make

small gains. This was probably due to the fact that measurements of thigh circumference at puberal onset were increased by a fatty layer which was subsequently lost during the puberal period, and the loss somewhat canceled the gain from muscle growth which was taking place.

The maximum growth in thigh circumference occurred for most boys during the puberal period for height, though the percentage (70.15 per cent) was less than for any of the skeletal measurements. The relation of the apex of thigh circumference to the apex of length measurements was quite variable, with no predominant pattern. There were only a few cases where thigh circumference apex was synchronous with either height, stem length, or leg length apex. In about half of the cases the apex occurred after leg length apex and before stem length apex.

The data for timing of apex occurrence as well as the total profiles of growth for leg length and thigh circumference strongly suggest that muscle girth and skeletal length develop asynchronously and by different patterns.

The profile configuration for thigh circumference differs markedly from the configurations of the five skeletal measurements studied. The curve for thigh circumference usually displays several widely separated periods of relatively high velocity, alternating with periods of low velocity or even loss in thigh circumference. The greatest acceleration is likely to occur during the latter part of the puberal period and during the postpuberal period. The thigh circumference profiles show a greater incidence of major peaks and dips than any other body dimension measured.

FOOTNOTES FOR CHAPTER XI

[1] The techniques of measurement are described in Chapter III.

[2] Of a total of 908 determinations made on the 67 boys, growth of thigh and arm agreed in timing and direction in 76.7 per cent, growth of thigh and leg in 82.5 per cent, and growth of leg and arm in 75.8 per cent.

[3] Complete data on thigh circumference measurements for 67 cases will be found in Appendix R.

[4] See Chapter XV for discussion of the 33 "fat boys."

[5] See Appendix H.

[6] See description of technique on page 26 in Chapter III.

Chapter XII CHANGES IN WEIGHT DURING ADOLESCENCE

DURING adolescence, as throughout life, changes in weight represent changes in mass of the body as a whole. In childhood, increase in weight is usually closely related to increases in skeletal dimensions. This relation persists during adolescence, but in this period the growth of the viscera, the growth of muscle tissue, the calcification of the skeleton, and the development of fatty tissue become increasingly important as components which determine body weight. From birth to maturity height increases, on the average, approximately three and a half times, while weight increases, on the average, twenty times.[1] It is common knowledge that human variability in weight is much greater than in height. These marked differences in weight among individuals show a rather abrupt increase in both frequency and magnitude, beginning with the prepuberal phase of the adolescent period.

In view of the many studies which have been made of the relation of weight to chronological age and to height, it is obvious that the addition of 67 cases to the thousands already tabulated to show these particular relations would be of very little value. However, there have been relatively few studies in which any attempt has been made to determine individual patterns of weight growth during the adolescent years and to relate those patterns to other aspects of development. It is now generally recognized that norms for weight based upon averages for children of a given chronological age and a given height must be interpreted for any given child in terms of that individual's maturity and morphology. In this chapter we will treat weight measurements as we have treated skeletal measurements, presenting the actual measurements in relation to given developmental points for height, the timing relation of the apex velocity in weight growth, and an analysis of configuration characteristic of the weight growth profiles.[2]

MEASUREMENTS AT DEVELOPMENTAL POINTS

As might be expected, our measurements show that during adolescence a marked increase in weight took place; but they also indicate that for individuals loss of weight often occurred from one examination to the next,

and that in some instances the period of loss lasted for a year or longer.

There was one case (Case 224) who weighed less at the onset of the puberal period (b) than he had a year and a quarter before at b — 3. This boy lost weight, also, over a space of a year and a quarter from d to d + 3 in the postpuberal period. Another boy (Case 86) weighed less at the puberal onset than he had at the examination just preceding. In both cases the loss resulted from a decrease in fatty tissue which was so great that it masked the growth gains in other tissues.[3] Of our sample, 71.64 per cent showed a decrease in weight during one or more of the interexamination periods. For these 48 cases such loss occurred once for 28 cases, twice for 12 cases, three times for 5 cases, four times for 1 case, and five times for 2 cases.

Table 69 CHANGES IN WEIGHT IN RELATION TO THE PUBERAL GROWTH PERIOD FOR HEIGHT—67 BOYS

A. KILOGRAMS

	Range	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3	*Inter-quartile Range*
Prepuberal (b − 3)	27.9–61.5	37.25	6.25	36.62	33.68	39.05	5.37
Onset of puberal (b)	31.4–65.5	41.42	6.13	40.58	37.75	43.61	5.83
End of puberal (d)	44.5–81.1	59.46	6.66	58.92	55.25	62.65	7.40
Postpuberal (d + 3)	49.8–89.5	64.44	6.51	64.00	60.70	68.17	7.47
Gain onset to end (b to d)	7.8–29.4	18.08	4.27	18.22	14.62	21.37	

B. POUNDS

	Range	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3	*Inter-quartile Range*
Prepuberal (b − 3)	61.50–135.58	82.12	13.78	80.74	74.25	86.09	11.84
Onset of puberal (b)	69.22–144.40	91.32	13.52	89.46	83.22	96.14	12.92
End of puberal (d)	98.10–178.79	131.08	14.68	129.89	122.80	138.12	15.32
Postpuberal (d + 3)	109.79–197.31	142.06	14.35	141.09	133.82	150.28	16.46
Gain onset to end (b to d)	17.20–64.81	39.92	9.40	40.51	32.36	47.12	

In Table 69 we have summarized the data concerning the weights of the 67 boys at comparable stages in their development. At b — 3 in the prepuberal period the mean weight was 37.25 kilograms [4] (82.12 pounds). This increased to 41.42 kilograms (91.32 pounds) by onset, and to 59.46 kilograms (131.08 pounds) by the end of the puberal period. The mean weight of the 67 boys was 64.44 kilograms (142.06 pounds) at d + 3 during the postpuberal period. It is evident that the range of weight difference was great. During the prepuberal period (b — 3) and at the onset of the puberal period the heaviest boy was more than twice as heavy as the lightest boy. From that point on, the ratio became less, but at the last determination there was an actual difference of 39.5 kilograms (87.52 pounds). The critical ratios of the difference of the weight measurements of the boys between each two consecutive developmental points was significant. (See Appendix X.)

The coefficient of variability for weight decreased steadily from the prepuberal period to the postpuberal period, the greatest change occurring from b to d. A comparison of the coefficients of variation for weight and height reveals that weight was between three and four times more variable at every point of comparison. (See Table 70.)

Table 70 COMPARISON OF VARIABILITY OF WEIGHT AND HEIGHT

	Coefficients of Variation	
	Weight	Height
Prepuberal (b − 3)	16.78	4.30
Onset of puberal (b)	14.80	4.02
End of puberal (d)	11.20	3.83
Postpuberal (d + 3)	10.10	3.65

The differences among the individual boys in weight at the four points are shown in the distribution of the 67 cases in Figures 144a, b, c, and d.

It will be seen that at each of the four points in development represented in these distributions there was a strong tendency toward compact grouping of cases about the mode, except for certain cases which appear at the extreme right. In the prepuberal period (at Point b — 3) Cases 236, 66, 74, and 224 seem to represent another order of magnitude, quite separate from the rest of the group.[5]

At Point b, where the puberal period for height begins, Case 236 has moved closer to the mode although still on the outskirts of the main group,

Kilograms	Case numbers
26	62
28	40, 100, 92
30	230, 116, 60
32	96, 72, 212, 24, 10, 242, 206, 84, 190, 180, 80, 108
34	164, 110, 68, 154, 44, 30, 26, 78, 166, 82, 64, 136
36	112, 106, 234, 32, 144, 304, 134, 130, 8, 294, 18, 176, 244, 220, 184
38	292, 52, 120, 218, 86, 54, 50, 168, 34, 58
40	216, 150, 88
42	146, 36
44	104, 250
46	
48	
50	
52	236
54	
56	74, 66
58	
60	224

FIGURE 144a. Distribution of 67 boys by case numbers according to weight in kilograms (2.2 pounds) at the third examination preceding onset of the puberal growth period for height (Point b — 3): mean, 37.25 kilograms; standard deviation, 6.25 kilograms; median, 36.62 kilograms; Q_1, 33.68 kilograms; Q_3, 39.05 kilograms.

Kilograms	Case numbers
30	62
32	100, 40, 92
34	60, 206, 26, 242, 230, 116
36	136, 96, 72, 78, 190, 108, 180, 80
38	58, 154, 68, 24, 294, 30, 10, 64, 166, 84, 86, 212
40	168, 150, 110, 130, 54, 304, 144, 82, 32, 244, 176, 18, 220, 164
42	8, 218, 34, 120, 184, 112, 44, 52, 134
44	292, 234, 50, 106
46	88, 216, 146
48	36, 250
50	104
52	236
54	
56	74
58	
60	224
62	
64	66

FIGURE 144b. Distribution of 67 boys by case numbers according to weight in kilograms (2.2 pounds) at the onset of the puberal growth period for height: mean, 41.42 kilograms; standard deviation, 6.13 kilograms; median, 40.58 kilograms; Q_1, 37.75 kilograms; Q_3, 43.61 kilograms.

Kilograms	Case numbers
44	92
46	60
48	24
50	100, 62
52	58, 176, 108, 40, 154, 96, 242
54	190, 206, 54, 86, 78, 164, 44, 72, 116
56	112, 304, 110, 134, 136, 130, 64
58	184, 32, 18, 80, 212, 230, 180, 88, 106, 10, 84
60	294, 220, 144, 236, 50, 30, 146, 26
62	36, 34, 120, 52, 250, 144, 68
64	8, 150, 166, 168, 218, 82, 292
66	
68	104
70	216
72	
74	224, 234
76	
78	66
80	74

FIGURE 144c. Distribution of 67 boys by case numbers according to weight in kilograms (2.2 pounds) at the end of the puberal growth period for height: mean, 59.46 kilograms; standard deviation, 6.66 kilograms; median, 58.92 kilograms; Q, 55.25 kilograms; Q_3, 62.65 kilograms.

Kilograms	Case numbers
48	60
50	92
52	24
54	
56	164, 96, 154, 62, 40
58	72, 176, 86, 242, 108
60	136, 44, 304, 212, 146, 184, 24, 78, 54, 190, 100, 58, 206
62	180, 230, 50, 220, 134, 80, 116
64	110, 106, 30, 112, 84, 250, 294, 120, 26
66	236, 82, 10, 244, 36, 34, 52
68	144, 218, 32, 166, 18, 88
70	104, 8, 292, 68, 168
72	150
74	224, 216
76	234
78	
80	66
82	
84	
86	
88	74

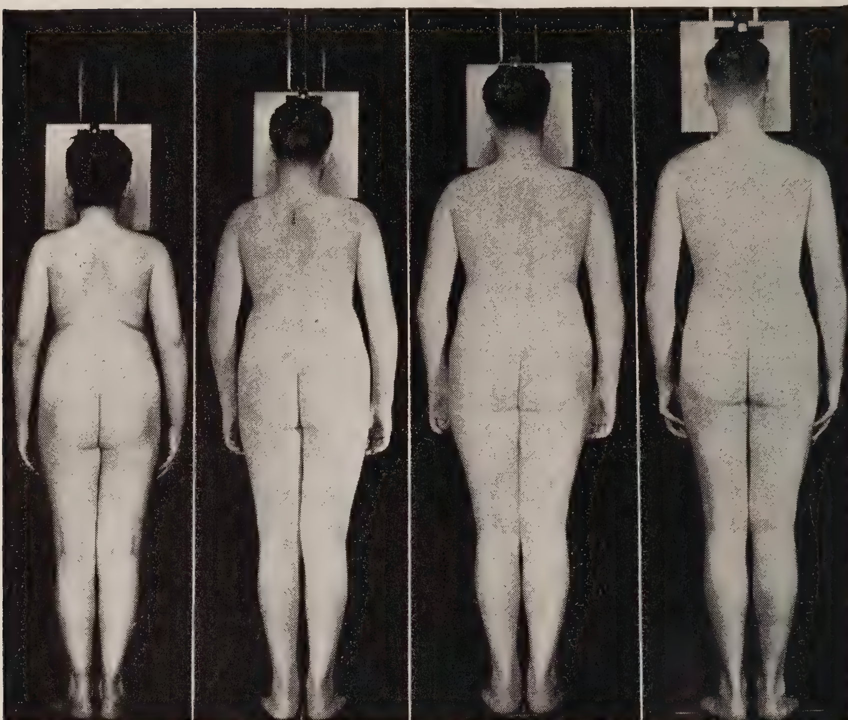
FIGURE 144d. Distribution of 66 boys by case numbers according to weight in kilograms (2.2 pounds) at the third examination following end of the puberal growth period for height (Point d + 3): mean, 64.44 kilograms; standard deviation, 6.51 kilograms; median, 64.00 kilograms; Q_1, 60.70 kilograms; Q_3, 68.17 kilograms.

and in the two succeeding distributions he will be found well within the third quartile. Cases 74, 66, and 224 remained consistently the three heaviest until the postpuberal period (d + 3), when Case 224 moved in slightly toward the mode. All four of these cases were weighted down with an unusually large amount of fatty tissue and muscle. In bulk of bone and muscle, Case 74 was in a class by himself, as far as our sample is concerned. In Figure 145a are shown photographs of Case 66 as he appeared about the time of each of the four weight determinations which have been discussed.

At the lower end of the distributions, Case 62 held the extreme position at the first two determinations but gravitated slightly toward the mode during the puberal and postpuberal periods, leaving Case 92 as the most consistent lightweight among the group. Photographs of Case 92 are shown in Figure 145b. As will be seen, he was small-boned, rather short, and scantily padded with subcutaneous tissue.

For comparison we show in Figure 146 photographs of a boy (Case 106) who remained close to the mean weight for the group throughout the adolescent growth period. Among the group there were several whose relative positions in weight changed considerably as they developed. Two examples of this (Cases 154 and 166) are shown in Figures 147 and 148.

The shortcomings of a weight standard for the selection of peers in physical development, or for athletic competition, are brought out by the finding that the heaviest boy at the prepuberal determination was 2.04 kilograms (4.5 pounds) heavier than the mean for the group at the end of the puberal period.



Case 66

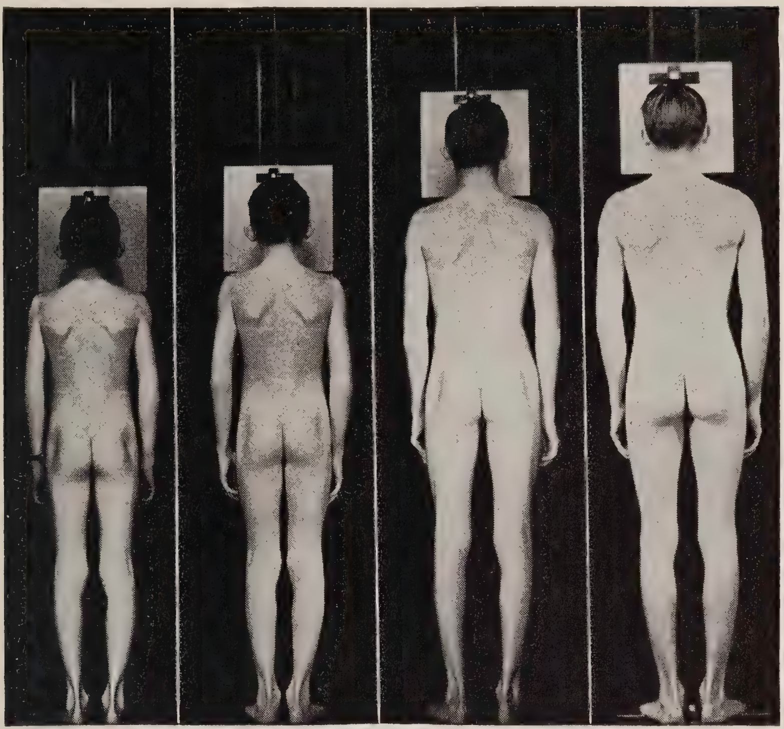
C.A. 12.2	13.6	15.6	17.0
Prepuberal	Puberal onset	Puberal end	Postpuberal

FIGURE 145a. Photographs of a boy taken during the prepuberal period, at the onset and end of the puberal period, and during the postpuberal period. This boy was one of the heaviest throughout adolescence.

GAIN IN WEIGHT DURING THE PUBERAL PERIOD

The mean gain in weight of the 67 boys during the puberal period for height was 18.08 kilograms (39.92 pounds). The distribution of the cases according to gain in weight is shown in Figure 149. One boy (Case 236) with a short duration gained only 7.8 kilograms (17.2 pounds), while another boy (Case 234) with a longer duration gained 29.4 kilograms (64.81 pounds). The correlation between gain in weight and duration was .633, P.E. ±.046. There were a few boys who made unusually high gains in short durations, including Cases 52, 40, and 80. There were also boys who made relatively low gains in long durations such as Cases 250, 54, and 164.

The correlation of gain in weight with height gain was .737, P.E. ±.037.



Case 92

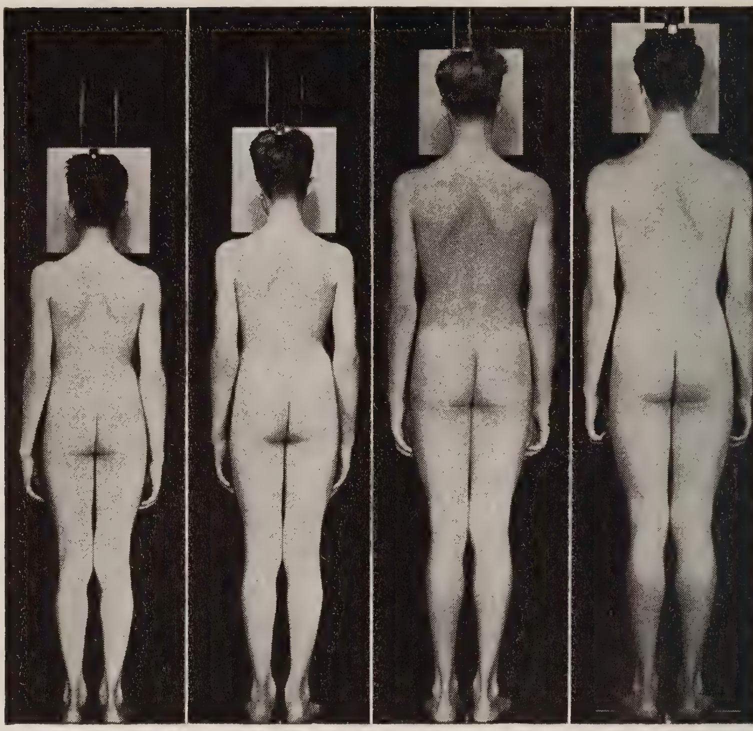
C.A. 12.3	13.6	15.6	16.9
Prepuberal	Puberal onset	Puberal end	Postpuberal

FIGURE 145b. Photographs of a boy taken during the prepuberal period, at the onset and end of the puberal period, and during the postpuberal period. This boy was one of the lightest in weight throughout adolescence.

Again we find Case 180 gaining less than his height would seem to warrant. Case 88, a boy of medium height gain was third from lowest in weight gain. In general, however, there were not many boys who diverged greatly from the typical relation. Weight gain correlated with stem length gain during the puberal period to about the same degree it did with height gain, the Pearson coefficient being .726, P.E.$\pm$.039.

The correlation of weight gain with gain in thigh circumference was slightly higher, .768, P.E. $\pm$.034. Case 74 gained proportionately more in weight than in thigh circumference, while Cases 10 and 84 made the highest gains in thigh circumference but were just above the mean in weight gain.

On the other hand, gain in weight during the puberal period showed a very low correlation with change in subcutaneous index during that period,



Case 106

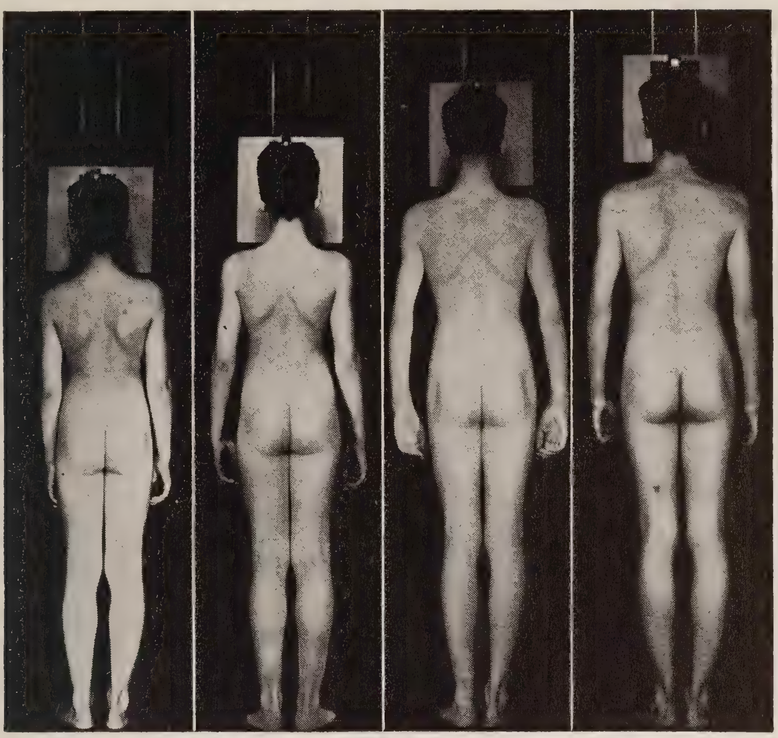
C.A.	12.6	13.6	15.6	16.9
	Prepuberal	Puberal onset	Puberal end	Postpuberal

FIGURE 146. This boy's weight remained close to the mean for the 67 cases at each of the four determinations.

the Pearson coefficient being .211, P.E. $\pm$.079. This would seem to indicate that gain in weight during the puberal period depends primarily upon increase in muscular tissue and only slightly upon changes in subcutaneous tissue.

TIMING RELATIONS BETWEEN APEX GROWTH FOR WEIGHT AND FOR LINEAR MEASUREMENTS

Weight apex and height apex. The apex of growth velocity in weight occurred within the puberal growth period for height in 85 per cent of our 67 cases; it preceded this period in 4.48 per cent and followed in 10.45 per cent.[6] The timing of the apex for weight ranged from 3.50 years before to 2.60 years after the height apex. Weight apex was synchronous with height apex in 13 cases (19.4 per cent), preceded height apex in 17 cases



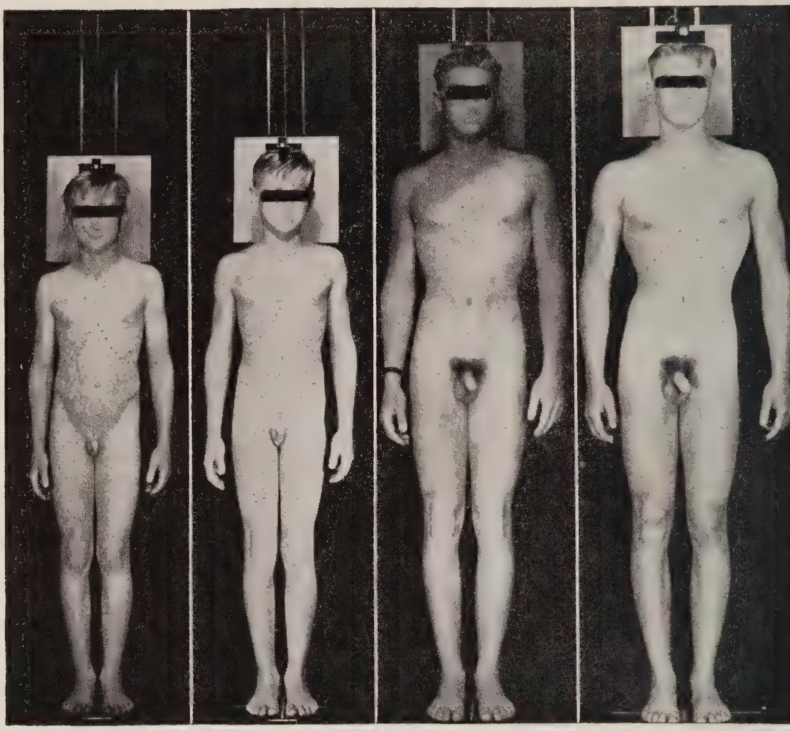
Case 154

C.A. 11.3	12.3	14.8	16.2
Prepuberal	Puberal onset	Puberal end	Postpuberal

FIGURE 147. During the prepuberal period this boy's weight was just below the mean for the group. During adolescence his relative weight position moved steadily downward until in the postpuberal period there were only 6 of 67 boys who weighed less than he did.

(25.37 per cent), and followed height apex in 37 cases (55.22 per cent). The growth velocity apex for weight occurred within .5 year of height apex in 52.24 per cent of the cases. These relations for the group are shown in Table 71.

We may conclude that, while there is wide variation in the timing relation between the apex velocity for weight and for height, there is a strong tendency for apex weight to occur at or after apex height. Some indication of one cause for early apex growth in weight is given by the findings that of the nine cases in which apex weight preceded apex height by more than .5 year, all were boys who exhibited obvious and measurable increase in subcutaneous tissue during the prepuberal period. This phenomenon of the early adolescent fat period will be discussed in detail in Chapter XV.



C.A. 11.5 — Prepuberal | 12.8 — Puberal onset | 16.3 — Puberal end | 17.5 — Postpuberal

FIGURE 148. At the onset of his puberal period the weight position of Case 166 in the group was just above Q_1. At the end of his puberal period his weight position was well above Q_3. At that time there were only 8 of the 67 boys who were heavier than he was.

Kilograms	Case numbers
6	
7	236
8	
9	
10	88, 24
11	
12	66, 92, 60, 44
13	134, 106, 146, 154, 176
14	130, 96, 54, 58, 36, 250, 112
15	304, 110, 224, 164
16	184, 86, 242, 108, 50
17	78, 104, 72, 64
18	190, 120, 292, 136
19	34, 62, 116, 84, 18, 32, 10, 100
20	212, 144, 52, 206
21	244, 220, 218, 30, 8, 40
22	80, 216, 68, 294, 180
23	230, 82
24	26, 150, 74, 168
25	
26	166
27	
28	
29	234

FIGURE 149. Distribution of 67 boys by case numbers according to gain in weight in kilograms (2.2 pounds) during the puberal growth period for height (b to d): mean, 18.08 kilograms; standard deviation, 4.27 kilograms; median, 18.22 kilograms; Q_1, 14.62 kilograms; Q_3, 21.37 kilograms.

Individual growth curves illustrating the several timing relations between puberal growth in weight and puberal growth in height are shown in Figures 150a, b, and c.

Weight apex, stem length apex, and leg length apex. A comparison of the relation of the apex of weight and the apex of stem length, with the relation of weight apex and leg length apex brings out some interesting facts about the growth of these 67 boys. Table 72, on page 293, summarizes these relationships.

Table 71 TIMING RELATIONS OF APEX WEIGHT TO APEX HEIGHT AND THE PUBERAL GROWTH PERIOD

Relation	*Number of Cases*	*Per Cent of 67 Cases*	*Years Difference* Average	Range
Apex weight synchronous with apex height	13	19.40		
Apex weight precedes apex height	17	25.37	1.05	.25–3.50
Apex weight precedes onset puberal growth period	3	4.48	2.65	1.90–3.50
Apex weight precedes apex height within puberal growth period	14	20.89	.76	.25–1.55
Apex weight follows apex height	37	55.22	1.14	.45–2.60
Apex weight follows end puberal growth period	7	10.45	2.00	1.50–2.55
Apex weight follows apex height within puberal growth period	30	44.78	.91	.45–2.60
Apex weight within ±.5 year of apex height	35	52.24		
Apex weight within puberal growth period	57	85.07		

There are 12 cases (17.90 per cent) where the apexes of weight and leg length are synchronous and 10 cases (14.92 per cent) where the apexes of weight and stem length are synchronous. Of these 22 cases, however, there is only 1 (Case 60) where all three apexes occur synchronously. Figure 151 on page 292 shows the growth curves for this case.

Weight apex follows leg length apex in 44 cases (65.67 per cent), but it follows stem length apex in only 29 cases (43.28 per cent).

There are 24 cases (35.82 per cent) where the weight apex follows both stem length and leg length apex. All of these cases also follow height apex. There are 9 cases (13.43 per cent) where weight apex precedes both stem length and leg length apex. These are the same 9 cases where weight apex preceded height apex by more than .5 year. They are discussed on page 287.

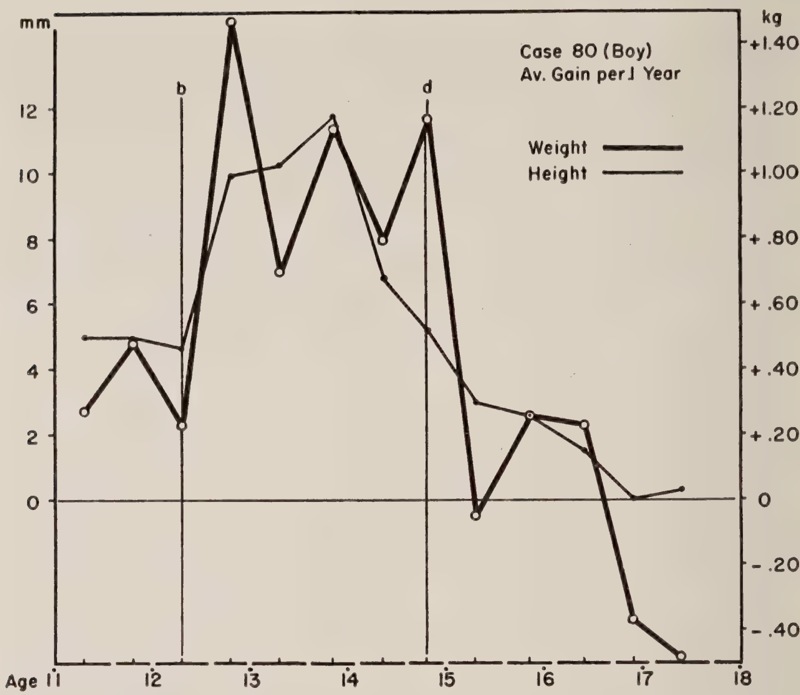


FIGURE 150a. Case 80 shows the growth velocity curve for weight reaching its apex 1.05 years before the height apex. This boy did not pass through an early adolescent fat phase. The weight apex was due to general tissue increase accompanying high-level growth in stem length, leg length, hip width, and shoulder width, but it did not coincide with apex growth in any one of these dimensions. However it was synchronous with a high apex growth in thigh circumference. It is possible, therefore, that growth in muscular tissue played a decisive part in determining the timing of the growth apex for weight. Growth curves of height, stem length, and leg length of Case 80 will be found in Figure 124b, page 218.

It seems evident that, while rapid growth in leg length and in stem length contributed very significantly to the increased velocity of weight growth during the puberal period, there are other components which play an important part in determining the timing of the apex velocity in weight growth. In this connection it is interesting to note that in the two cases, shown in Figures 128a and b on pages 230 and 231, in which there was synchrony of apex growth for height, leg length, stem length, biacromial width, and bi-iliac width, the apex growth in weight *did not* occur at the same time but came .95 year later in Case 92 and 1.50 years later in Case 144.

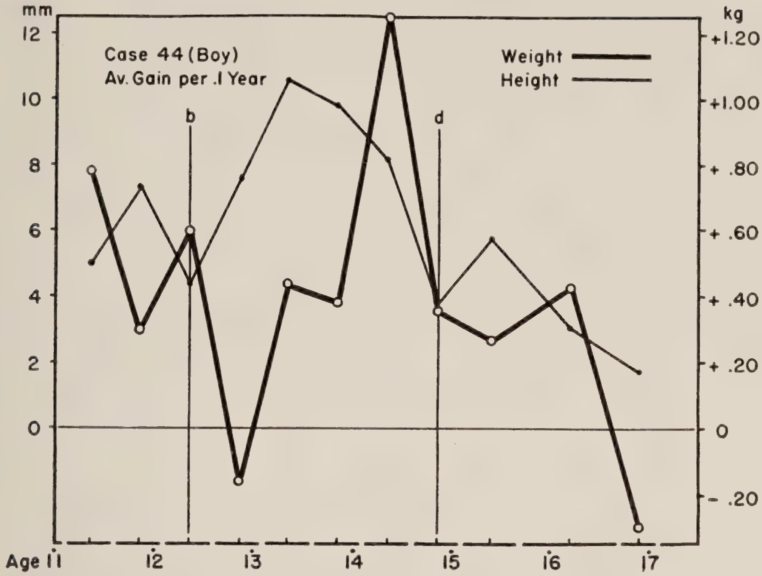


FIGURE 150b. In Case 44 the apex of growth velocity in weight occurred 1.00 year after the height apex. In more than half (55.22 per cent) of the 67 cases this was the sequential pattern. The apex for weight for Case 44 was synchronous with the apex for thigh circumference.

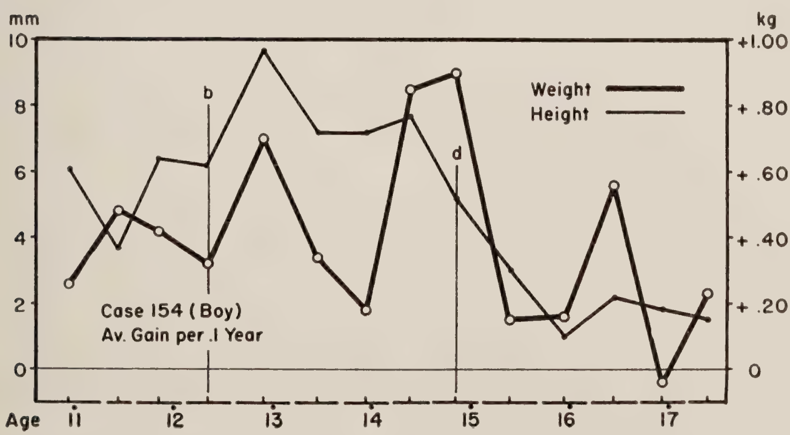


FIGURE 150c. Case 154 shows the weight apex occurring 1.95 years after the height apex. Although this sequence is the most common, the lag of the puberal weight apex is rarely as long as this. In this case there was marked growth in thigh circumference synchronous with the weight apex, but the maximum growth in thigh circumference occurred during the prepuberal period.

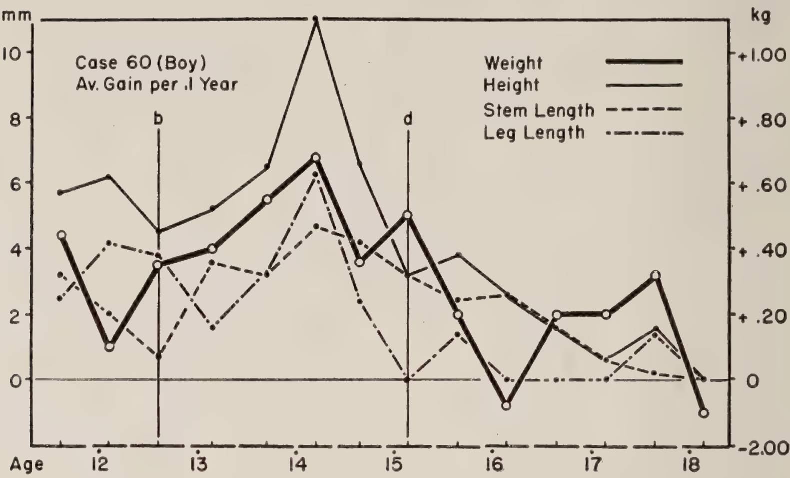


FIGURE 151. Case 60 is one of the thirteen cases in which weight apex and height apex were synchronous. This is the only boy in whom both leg length and stem length apexed at the same time. This boy was one of the lightest in weight throughout adolescence and had no outstanding apex in thigh circumference growth.

TIMING RELATIONS BETWEEN APEX GROWTH FOR WEIGHT, THIGH CIRCUMFERENCE, AND SUBCUTANEOUS TISSUE

Weight apex and apex for subcutaneous tissue index. Since only 27.69 per cent of the boys had the apex for subcutaneous tissue growth during the puberal period,[7] it is not surprising to find that there were relatively few cases where weight apex and subcutaneous tissue apex were synchronous (6.15 per cent). In over half of 65 cases (52.31 per cent) weight apex followed subcutaneous tissue apex, and in 41.54 per cent it preceded subcutaneous tissue apex.[8] This shows that during adolescence the maximum increase in rate of weight growth rarely, if ever, depends primarily on increase in subcutaneous tissue.

Weight apex and thigh circumference apex. Weight apex, however, is more closely related to the apex of thigh circumference. In 40.30 per cent of the 67 boys the maximum growth of these two measures occurred synchronously. This is the closest synchrony we have found in any two measurements, except for the relation of height apex to leg length apex. Of the remaining cases by far the largest percentage (43.28 per cent) had the weight apex following the apex for thigh growth. The difference in timing ranged from .25 year to 4.5 years. The remaining 16.42 per cent of the weight apexes preceded thigh apex from .5 year to 3.5 years.

In Table 73 we show the relations in timing of weight apex with the apexes of both thigh circumference and subcutaneous tissue for 65 cases.

Table 72 TIMING RELATIONS OF WEIGHT APEX TO STEM LENGTH APEX AND LEG LENGTH APEX

A. NUMBER OF CASES

Timing Relations of Weight Apex to Stem Length Apex	*Timing Relations of Weight Apex to Leg Length Apex* Before	Synchronous	After	Total
Before	9	6	13	28
Synchronous	2	1	7	10
After		5	24	29
Total	11	12	44	67

B. PERCENTAGE OF 67 CASES

Timing Relations of Weight Apex to Stem Length Apex	*Timing Relations of Weight Apex to Leg Length Apex* Before	Synchronous	After	Total
Before	13.43	8.95	19.40	41.79
Synchronous	2.98	1.49	10.45	14.92
After		7.46	35.82	43.28
Total	16.41	17.90	65.67	99.99

There is no one predominant pattern, but the largest percentage of cases (24.62 per cent) had weight apex following both thigh and subcutaneous tissue apex.

The two profiles shown in Figure 152 illustrate the strong tendency toward configurational similarity between growth in weight and thigh circumference which we found in our sample.

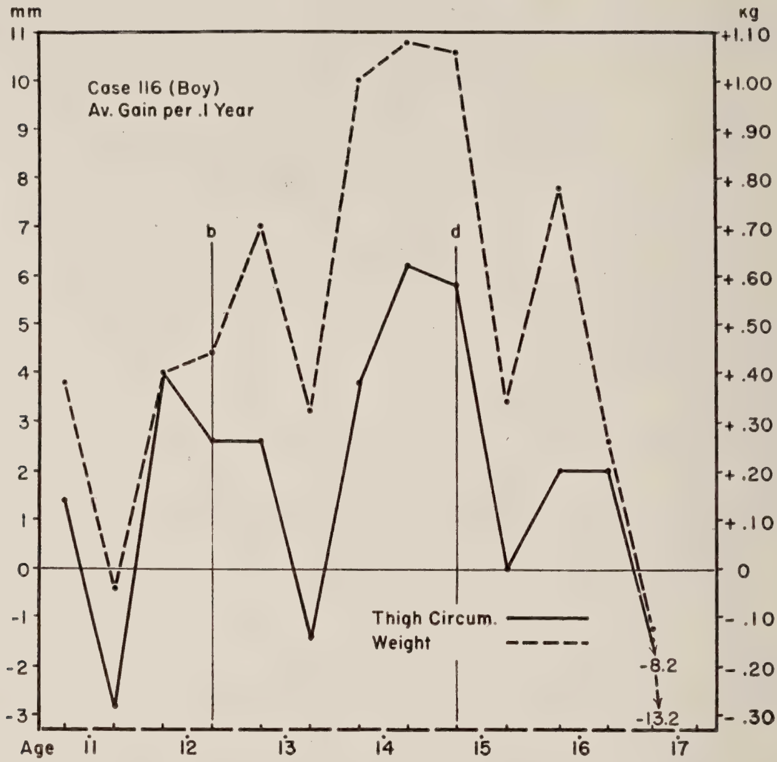


FIGURE 152. These profiles for Case 116 illustrate the striking similarity of the patterns and the strong tendency toward synchrony for weight growth and thigh circumference growth in boys during adolescence.

CONFIGURATION OF THE GROWTH PROFILE FOR WEIGHT

From the inspection of the weight growth profiles and by comparison with the height growth curves, it is obvious that there are significant differences between the pattern of growth for height and that for weight during adolescence. This impression is fully substantiated by detailed profile analysis.

In the course of the twelve to fourteen determinations, upon which the profiles are based, for each of the 67 cases, major changes of velocity from below to above the five year average for each case occur 108 times in the height profiles, 185 times in the weight profiles.[9] The profiles for height show only one instance of a major dip to zero; those for weight show a major dip to zero or below 39 times. Thus, the major variations in velocity of weight growth during this period occur more than twice as often (224:109) as do those for height. In Figures 153a, b, and c we show specimen comparisons of the growth velocity profiles for height and weight. In one case (Case 50) the ratio of frequency of major changes in velocity

Table 73 TIMING RELATIONS OF WEIGHT GROWTH APEX WITH APEX OF SUBCUTANEOUS TISSUE AND APEX OF THIGH CIRCUMFERENCE—65 BOYS

	Relation of Weight Apex to Thigh Apex							
	Preceding		Synchronous		Following		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Relations of Weight Apex to Subcutaneous Tissue Apex: Preceding	5	7.69	12	18.46	10	15.38	27	41.54
Synchronous			1	1.54	3	4.62	4	6.15
Following	6	9.23	12	18.46	16	24.62		
Total	11	16.92	25	38.46	29	44.62	65	100.00

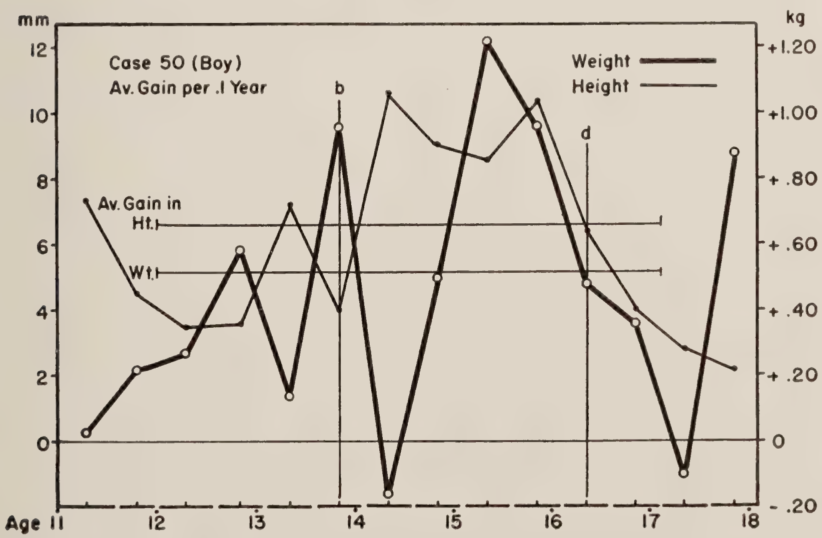


FIGURE 153a. These profiles of growth velocity in height and weight for Case 50 illustrate an instance in which there were 6 major changes in weight growth velocity to 2 in height growth velocity during the adolescent period. There were eleven cases (16.42 per cent) which had the same ratio.

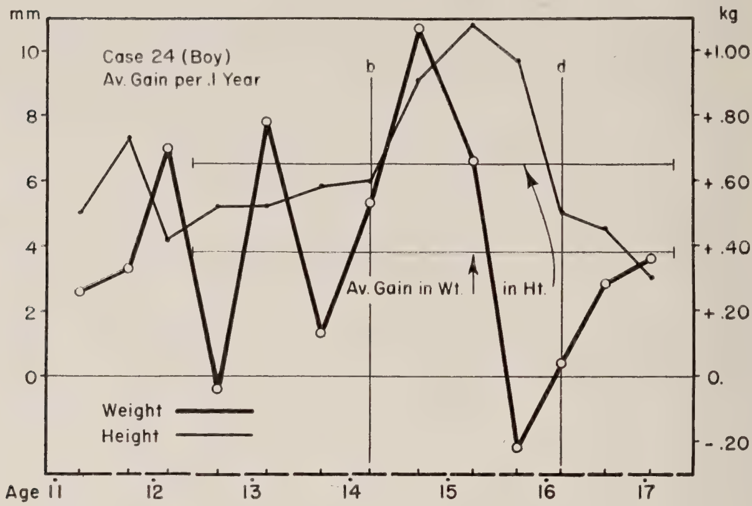


FIGURE 153b. These profiles illustrates an instance (Case 24) in which there were 5 major changes in weight growth velocity to 2 in height growth velocity. There were thirteen cases (19.40 per cent) which had the same ratio.

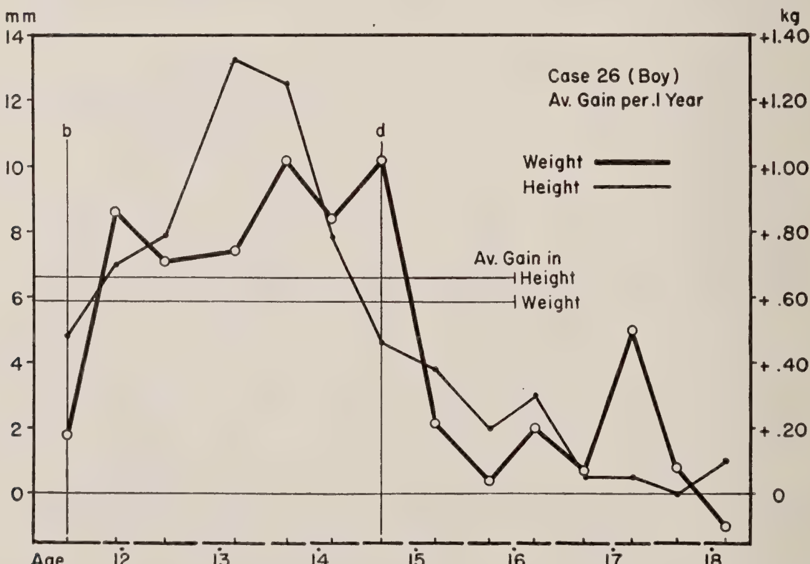


FIGURE 153c. These profiles show one of the three cases in which the ratio of major changes in height growth velocity and weight growth velocity was 1 to 1. It will be noted that the minor flexions in the weight growth profile are more numerous and more obvious than in the height growth profile. There were eight cases (11.94 per cent) which had the same number of peaks and dips in the two curves.

between weight and height is 3 to 1; in another (Case 24) the ratio is 5 to 2; in a third (Case 26) the ratio is 1 to 1.

SUMMARY

Although every boy in our sample gained weight during adolescence, the growth of mass for some tissues was quite frequently masked for short periods by losses of mass in other tissues. During the seven year period over two thirds or 71.64 per cent of the boys showed loss once; twelve showed loss twice; five, three times; one, four times; and two, five times.

At Point b — 3 early in the prepuberal period, their weights ranged from 27.9 kilograms (61.5 pounds) to 61.5 kilograms (135.58 pounds); at Point d + 3, late in the postpuberal period, they ranged from 49.8 kilograms (109.79 pounds) to 89.5 kilograms (197.31 pounds). The interquartile range increased slightly at each determination (b — 3, b, d, d + 3), but the total range increased much more noticeably owing to a few extreme cases. The coefficient of variability was three to four times as great as for height.

Individual cases illustrated the interaction of changing mass ratios of fatty tissue and other tissues in determining weight at successive developmental points. During the prepuberal period and at the onset of the puberal period, the heaviest boy weighed more than twice as much as the lightest.

The mean gain in weight during the puberal period (b to d) was 18.08 kilograms (39.92 pounds) with a range of from 7.8 kilograms (17.2 pounds) to 29.4 kilograms (64.81 pounds). The correlation between duration of the period and weight gained was .663, P.E. ±.046, but a few boys made unusually great gains in short durations and a few made relatively small gains in long durations. The correlation between gain in weight and in height was .737, P.E. ±.037; between gain in weight and in thigh circumference, it was .768, P.E. ±.034.

Apex growth in weight occurred within the puberal period for height in 85.00 per cent of the cases but was synchronous with height in only 19.4 per cent. The weight apex preceded the height apex in 25.37 per cent and followed height apex in 55.22 per cent. Except in cases which manifested a marked early adolescent fat period, maximum growth in weight usually occurred with or after maximum growth in height.

Weight growth apex followed leg length apex in 65.67 per cent of the cases, and they were synchronous in 17.90 per cent. The apexes for weight and thigh circumference occurred synchronously in 40.30 per cent and weight followed thigh in 43.28 per cent. Changes in weight were apparently more closely related in timing to growth in thigh circumference and to changes in amount of fatty tissue than to any of the other growth phenom-

ena studied. The effects upon weight of growth in leg length and stem length were less obvious in the timing relations of the growth profiles.

Growth profiles for weight show significant differences of pattern from those for height. Major peaks and dips occur on the average more than twice as often, and in individual cases four times as frequently. Minor fluctuations from one examination to the next are both more frequent and more obvious.

FOOTNOTES FOR CHAPTER XII

[1] Harvey, B. C. H.: *Human Anatomy.* American Medical Association, Chicago, 1931; p. 425.

Scammon, R. E.: "The Measurement of the Body in Childhood" in *The Measurement of Man* by Harris, Jackson, Paterson, and Scammon, University of Minnesota Press, Minneapolis, 1930.

[2] Complete data for 67 boys upon which this chapter is based will be found in Appendix S.

[3] There was no evidence of any illness which would account for such loss in weight.

[4] One kilogram equals 2.204 pounds.

[5] See discussion of these cases in Chapter XV.

[6] Case 18 had his highest gain in weight during two consecutive examination periods and the mid-point between examinations was taken as the apex age.

Case 26 had equal maximum gain in weight at two periods .95 of a year apart and not contiguous—both within the puberal growth period and both following the height apex. The apex nearest the height apex was used.

[7] See Chapter X.

[8] Data incomplete for Case 66. Case 112 had two apexes for subcutaneous tissue, and weight apex was between them.

[9] For a detailed description of the method used for determining the frequency of major inflexions of growth velocity profiles, see page 114.

Chapter XIII GROWTH IN STRENGTH DURING ADOLESCENCE

THE sampling of muscular strength in our cases consisted of routine measurements with the dynamometer at each examination.[1] We measured the grip pressure of each hand, the strength of those muscles which thrust the hands together in front of the chest, and the strength of those muscles which pull the hands apart from in front of the chest. It is regrettable that a more fully representative set of measures, including some measure of leg strength, were not included in the schedule, because even the limited data secured on growth in strength have proved particularly useful in illuminating the patterns of growth.

Theoretically, measures of strength which require the cooperative effort of the subject are somewhat suspect, and of course the boys in our sample did not always put forth maximum effort. However, at this period of development pride in physical prowess is almost universal among healthy males, and usually the examiner found no need to urge the subject to greater effort but had to prevent him from trying again and again.

Certainly, strength varies with general physiological status and occasionally a boy would show a loss in test achievement which undoubtedly was due to lack of sleep, recent digestive disturbance, upper respiratory infection, or other temporary physical handicap. Yet it should be remembered that the tests used were of but a few seconds' duration and made little call upon the circulatory system.

In any case, the rhythm of growth in muscular strength, as measured, shows a marked similarity to the rhythm pattern of skeletal measures which cannot be affected by transitory variations in physiological status or will to achieve. This similarity will become evident as we describe the findings and as the reader studies the individual profiles.

For purposes of statistical treatment we have added the results of the right hand grip, left hand grip, "thrust," and "pull" together as a sample measurement to represent muscular strength at a given examination. Strength score is the summation of these four measurements. All references to strength, muscular strength, or strength score in this study refer to this summation.

MEASUREMENTS OF STRENGTH AT DEVELOPMENTAL POINTS

The strength scores as determined at b — 3 in the prepuberal period, at the onset of the puberal period for height (b), at the end of that period (d), and at d + 3 in the postpuberal period have been arranged to show the distribution of cases in Figures 154a, b, c, and d.[2]

In the prepuberal period (Figure 154a) our sample showed a compact distribution with the strongest boy (Case 66) having a strength score 56.0

					166							
					116		234					
					112		26					
					88		104					
					78	74	224	150				
				18	82	30	206	36				
			146	62	64	96	134	34				
			216	52	212	54	68	32				
			244	10	180	120	50	294		176		66
	100		242	144	168	60	136	110		184		292
	86	164	72	58	154	190	250	44	24	130		236
	108	92	40	230	84	80	8	304	220	106		218
Kilograms	65	70	75	80	85	90	95	100	105	110	115	120

FIGURE 154a. Distribution of 67 boys by case numbers according to strength score at the third examination preceding the onset of the puberal growth period for height: mean, 92.95 kilograms; standard deviation, 13.25 kilograms; median, 92.19 kilograms; Q_1, 84.10 kilograms; Q_3, 100.78 kilograms.

									50						
							32		154						
						78	216	134	44	104					
					180	120	166	24	294	184					
					82	116	304	10	62	8					
					92	112	144	150	96	36					
				146	244	212	250	168	206	106	60				
				242	30	88	18	52	190	234	224		220		
	86		72	64	230	84	54	110	74	68	130		236		
	58	108	100	40	80	164	136	26	34	176	218		66		292
Kilograms	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140

FIGURE 154b. Distribution of 67 boys by case numbers according to strength score at the onset of the puberal growth period for height: mean, 105.12 kilograms; standard deviation, 14.18 kilograms; median, 105.31 kilograms; Q_1, 95.47 kilograms; Q_3, 114.62 kilograms.

																		166			
									54	80								220			
									244	230	294							184			
							154		134	136	110	36						74			
							82		78	120	104	68	304	150	190			292			
				164			108	64	116	10	66	168	144	34	206			130			
		86		146	112		40	250	30	176	24	32	84	180	8		26	62			
	72	92	100	58	88		18	242	44	96	236	60	216	52	212	106	224	50		218	234
Kilograms	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220

FIGURE 154c. Distribution of 67 boys by case numbers according to strength score at the end of the puberal growth period for height: mean, 172.42 kilograms; standard deviation, 24.22 kilograms; median, 171.25 kilograms; Q_1, 157.90 kilograms; Q_3, 189.06 kilograms.

Kilograms	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255
																50							
														116		26							
												40		34		110							
												230		10	216	212							
								100	30			120	108	180	18	220	106	144					
							96	54	146	64	104	242	36	136	304	168	8	74		62			
				58		176	236	78	24	112	44	88	294	84	150	32	224	52		166			
	72	86		164		92	244	80	250	60	154	66	206	82	68	190	134	184		292		234	218

FIGURE 154d. Distribution of 66 boys by case numbers according to strength score at the third examination following the end of the puberal growth period for height: mean, 207.12 kilograms; standard deviation, 23.59 kilograms; median, 210.00 kilograms; Q_1, 189.38 kilograms; Q_3, 223.75 kilograms.

kilograms (123.46 pounds) greater than the weakest boy (Case 108).[3] At Point b, approximately 1.25 years later, the difference had increased to 68.0 kilograms (149.91 pounds) and the distribution had flattened out slightly. (See Figure 154b.) At the end of the puberal period (d) the form of the distribution had changed quite noticeably. (See Figure 154c.) The strongest boy registered a strength score 100.5 kilograms (221.56 pounds) greater than the weakest boy, and the distribution had flattened out markedly, with a piling up of cases at the right. At Point d + 3 in the postpuberal period (see Figure 154d) the range had increased still further, with a difference between weakest and strongest of 111 kilograms (244.71 pounds). The critical ratios of the difference in measurements of strength between each two consecutive developmental points were significant. (See Appendix X.)

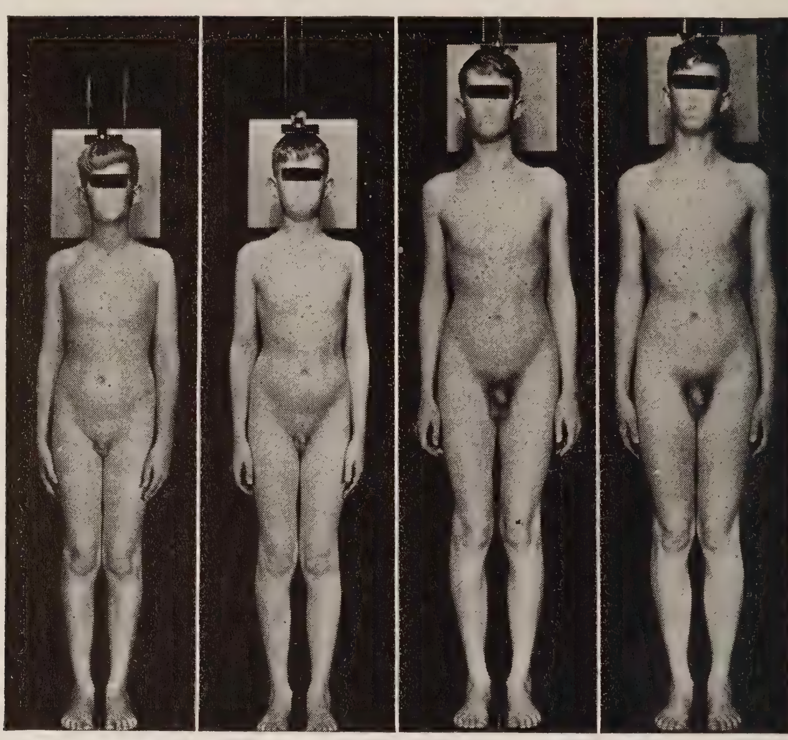
Table 74 INCREASE IN STRENGTH SCORE IN RELATION TO THE PUBERAL GROWTH PERIOD FOR HEIGHT—67 BOYS

A. IN KILOGRAMS

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3
Prepuberal (b − 3)	66.5–122.5	92.95	13.25	92.19	84.10	100.78
Onset of puberal (b)	72.0–140.0	105.12	14.18	105.31	95.47	114.62
End of puberal (d)	123.0–223.5	172.42	24.22	171.25	157.90	189.06
Postpuberal (d + 3)	148.0–259.0	207.12	23.59	210.00	189.38	223.75
Puberal gain (b to d)	32.5–107.0	68.70	17.39	68.33	54.50	81.13

B. IN POUNDS

Time of Measurement	*Range*	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3
Prepuberal (b − 3)	146.6–270.0	204.90	29.20	203.20	185.40	222.20
Onset of puberal (b)	158.7–308.6	231.80	31.30	232.20	210.50	252.70
End of puberal (d)	271.2–492.7	380.10	53.40	377.50	346.70	416.80
Postpuberal (d + 3)	326.3–571.0	456.60	52.00	463.00	417.50	493.30
Puberal gain (b to d)	71.6–235.9	151.35	38.31	150.33	120.06	178.73

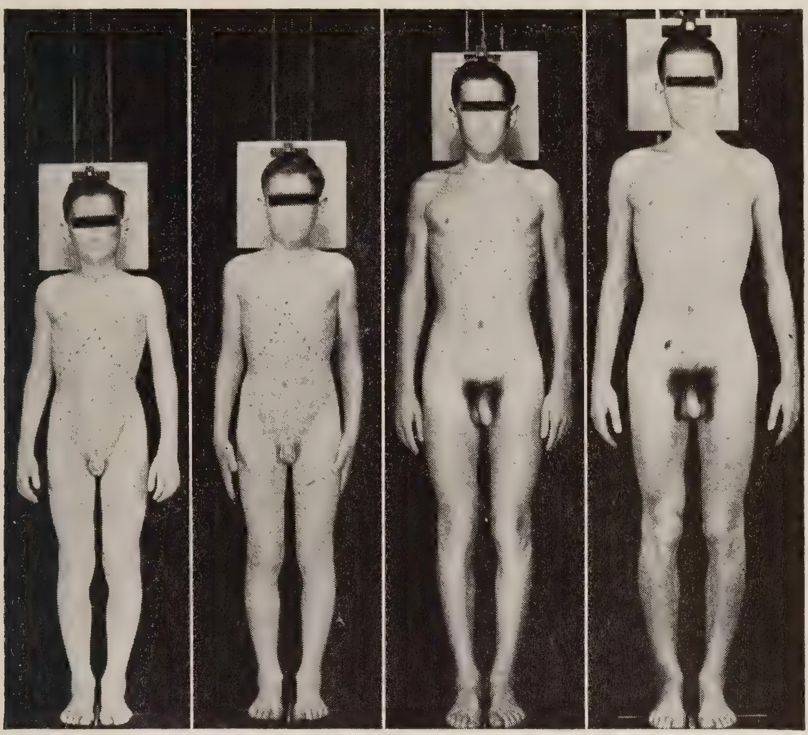


C.A. 12.1 — Prepuberal; 13.2 — Puberal onset; 16.3 — Puberal end; 17.6 — Postpuberal

FIGURE 155a. This boy (Case 58) was among those who showed least muscular strength at each of the four determinations during adolescence.

That there was considerable change in position of individuals relative to the group is evidenced by the small number which remained in any given quartile throughout the period covered by the four determinations. Of the 67 cases 6 remained consistently in the first quartile, 1 in the second quartile, none in the third quartile, and 3 in the fourth quartile. There were 5 cases which consistently maintained positions between Q_1 and Q_3 at all four determinations. In Figures 155a, b, and c we show photographs of three boys who retained relatively consistent positions: Case 58 in the lowest, Case 136 in the middle, and Case 218 in the upper group. The correlation between strength rating during the prepuberal period (b — 3) and during the postpuberal period (d + 3) was .331, P.E. ±.074. The correlation between strength rating at the onset and end of the puberal period was .678, P.E. ±.045.

The increases in strength score in relation to the puberal growth period for height are summarized in our sample in Table 74, page 301.



C.A. 11.3	12.6	15.7	16.9
Prepuberal	Puberal onset	Puberal end	Postpuberal

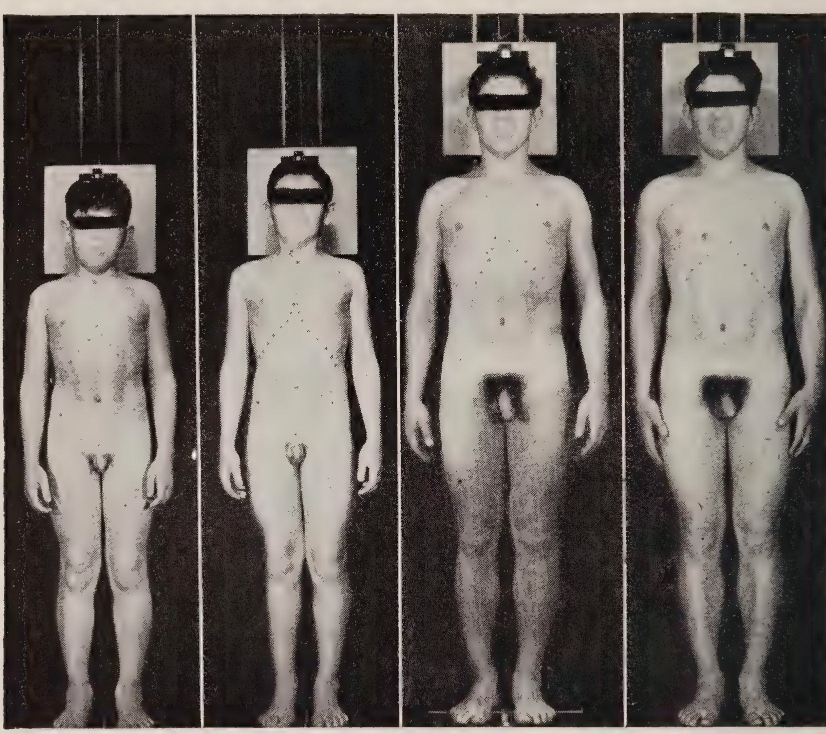
FIGURE 155b. This boy (Case 136) maintained an unusually stable position relative to the group as regards strength during the adolescent period. His strength score fell between Q_1 and Q_3 at all four determinations.

It will be noted that there is very little overlapping between the successive interquartile ranges, which suggests that a suitable strength score would be an important factor for determining the classification of adolescent boys for competition in physical activities. Special adaptations would need to be made for the more extreme deviants.

A comparison of the magnitude of the coefficients of variability for strength with those for weight shows that individuals differ less in strength at the first two determinations and more in the latter two determinations. (See Table 75.) The increase in variability from onset to end of the puberal period is due to the late occurrence of the maximum growth in strength discussed on page 307.

GAIN IN STRENGTH DURING THE PUBERAL PERIOD FOR HEIGHT

In Figure 156 is shown the distribution of our sample according to gain in muscular strength achieved during the puberal growth period for height.



C.A. 12.6	13.9	17.0	17.7
Prepuberal	Puberal onset	Puberal end	Postpuberal

FIGURE 155c. This boy (Case 218) despite his short stature, was consistently among those showing the greatest muscular strength at each successive phase of adolescent development.

Table 75 COEFFICIENTS OF VARIABILITY OF STRENGTH AND WEIGHT

Time of Measurement	*Strength*	*Weight*
Prepuberal (b − 3)	14.25	16.78
Onset of puberal (b)	13.49	14.80
End of puberal (d)	14.05	11.20
Postpuberal (d + 3)	11.39	10.10

The range was from 32 kilograms to 107 kilograms (71.60 pounds to 235.90 pounds). The average gain for the group was 68.70 kilograms with a standard deviation of 17.39 kilograms.

One is not surprised to find that Case 92, whose photographs have been shown in Figure 145b on page 285, gained least in strength during the puberal period (b to d). He was asthenic in type, and his puberal growth period for height was very short (2.0 years). But it is surprising to find that Case 72 made next to the smallest gain (39.5 kilograms, or 87.08

							116				130					
					250		78	120	8		190					
					104		40	168	108		206					
				18	96		58	136	32	80	304		212			
			164	146	134		54	242	244	216	150		62			
			66	44	100	82	24	10	64	230	144		184	218		
			154	88	60	10	294	68	30	52	106		180	26		234
	92	72	236	112	176	86	36	292	34	220	224	84	50	74		166
Kilograms	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105

FIGURE 156. Distribution of 67 boys by case numbers according to the amount of gain in strength score during the puberal period for height: mean, 68.70 kilograms; standard deviation, 17.39 kilograms; median, 68.33 kilograms; Q_1, 54.50 kilograms; Q_3, 81.13 kilograms.

pounds). As will be seen from his photographs in Figure 157c, he was rather tall, (in the third quartile at Point d) well proportioned, and did not look like a weakling. His consistently poor showing in the strength tests was perhaps partly due to his unwillingness to put forth his best effort. But back of this lay a disturbed personality for whom the experiences of adolescence proved particularly difficult. In his case the duration of the puberal period was well above the average for the group, and at Point d + 3 in the postpuberal period his strength score was still the lowest.

During the puberal period Case 234 showed the greatest gain in strength score, closely followed by Case 166. A photograph of Case 166 is shown

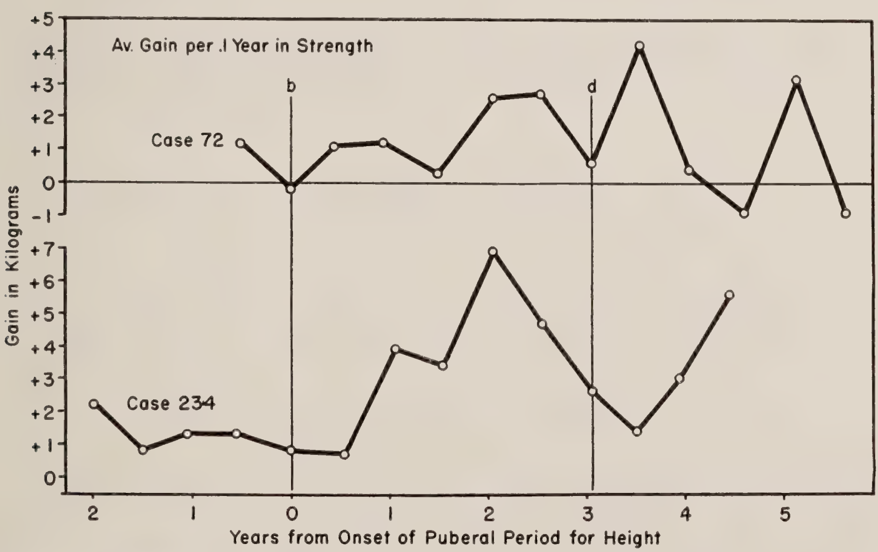
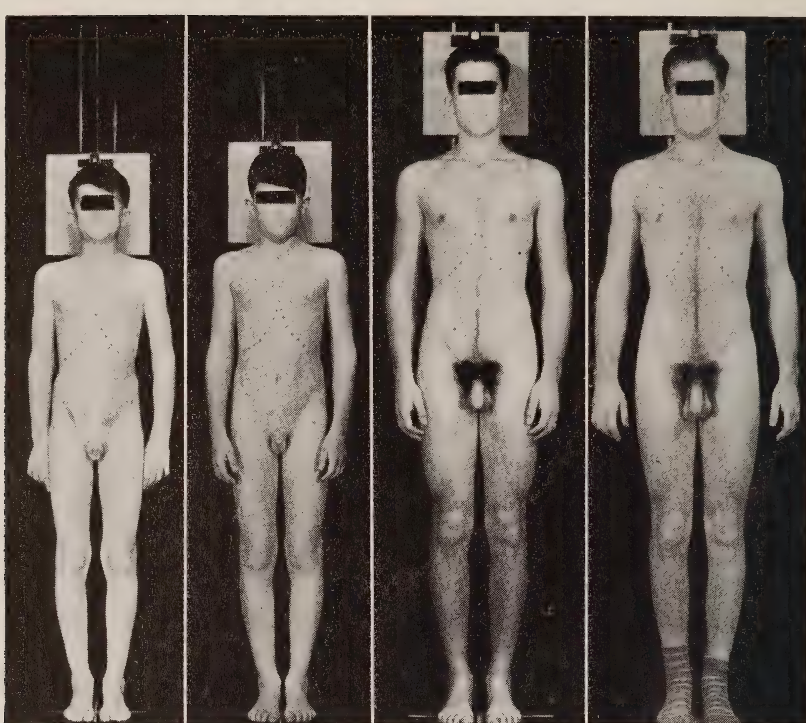


FIGURE 157a. These two profiles illustrate the extremes of gain in muscular strength among the boys of our sample. During the puberal period for height Case 72 gained 39.5 kilograms (87.1 pounds) in 3.05 years, while Case 234 gained 107 kilograms (235.9 pounds) in exactly the same time.



C.A. 11.8 | 13.1 | 16.1 | 17.3
Prepuberal | Puberal onset | Puberal end | Postpuberal

FIGURE 157b. The strength increase of Case 234 during the puberal growth period for height was the greatest among the group. His score rose from 116.5 kilograms (256.84 pounds) to 223.5 kilograms (492.73 pounds) in three years. He also made large gains in thigh circumference. (See growth curve in Figure 157a).

Table 76 RATE OF GAIN IN STRENGTH INDEX DURING ADOLESCENCE *—67 BOYS

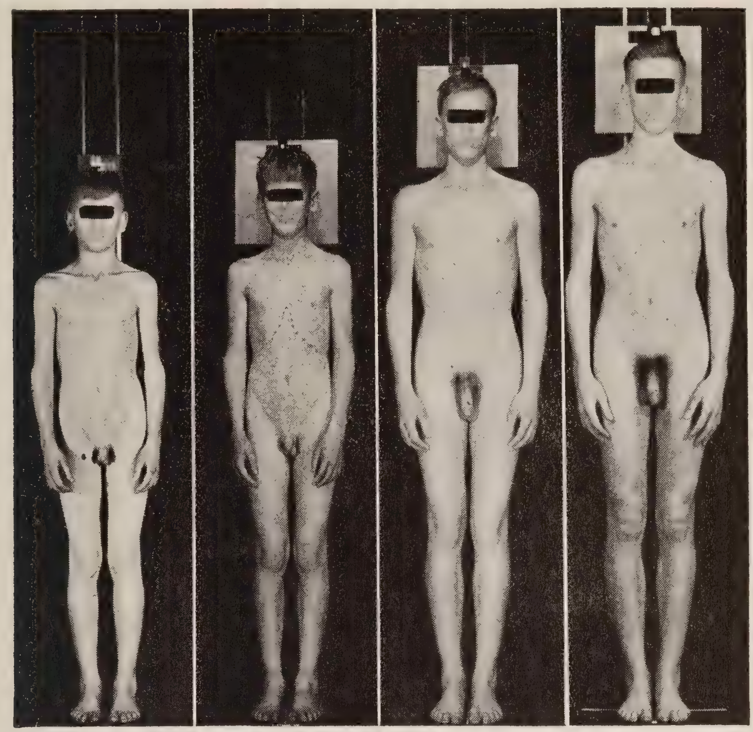
	Kilograms
Average yearly prepuberal gain (b − 3 to b)	9.74
Average yearly puberal gain (b to d)	23.95
Average yearly postpuberal gain (d to d + 3)	27.76

* This table was prepared by taking the difference of the means and dividing by the average duration of the period. (Refer to Table 74.)

in Figure 148 on page 288 and of Case 234 in Figure 157b.

The profiles of velocity of gain in strength for Cases 234 and 72, presented in Figure 157a on page 305, show an interesting contrast.

If we compare the mean puberal gains with the prepuberal and postpuberal gains, we find that the group made larger gains during the postpuberal years than during the puberal period. This is in marked contrast



C.A. 11.3 Prepuberal | 12.1 Puberal onset | 15.1 Puberal end | 17.0 Postpuberal

FIGURE 157c. Photographs of Case 72 who made next to the smallest gain in strength during the puberal period for height. From the standpoint of his other somatic characteristics this was surprising. One must look for the causes in emotional disturbances in his personality development.

to the gains in any of the measurements analyzed so far. (See Table 76.) This is due to the timing of the maximum growth velocity for strength, to be discussed in the next section.

There was a high correlation between the gains in strength and the gains in weight during the puberal period, the Pearson coefficient being .639, P.E.$\pm$.049.

TIMING OF APEX GROWTH FOR STRENGTH

In relation to height. In two thirds of our cases the apex velocity of growth in strength occurred within the puberal growth period for height; in only one case (1.51 per cent) did it come before that period; in a little less than one third of the cases it came after the end of that period.

This tendency for increase in strength to lag behind increase in stature is further emphasized by the timing relations between the two apexes. Apex

strength preceded apex height in 12.12 per cent of the cases; they were synchronous in 10.61 per cent of the cases; apex strength came after apex height in 77.27 per cent of the cases.

The extent of this lag in strength growth is indicated by the finding that the average lag was 1.59 years and that in only 30.3 per cent of the cases did apex strength occur within ±.5 year of apex height. These and other timing relations are summarized in Table 77.

Table 77 TIMING OF APEX FOR STRENGTH IN RELATION TO APEX FOR HEIGHT AND PUBERAL GROWTH PERIOD FOR HEIGHT

Relation	*Number of Cases*	*Per Cent of 66* Cases*	*Years Difference* Average	*Years Difference* Range
Apex strength synchronous with apex height	7	10.61		
Apex strength precedes apex height	8	12.12	.83	.50–1.45
Apex strength precedes onset puberal period for height	1	1.51	1.45	
Apex strength precedes apex height within puberal period	7	10.61	.70	.50–1.00
Apex strength follows apex height	51	77.27	1.59	.45–5.00
Apex strength follows end puberal period height	21	31.82	2.47	1.15–5.00
Apex strength follows apex height within puberal period height	30	44.78	1.07	.45–2.00
Apex strength within ±.5 year of apex height	20	30.30		
Apex strength within puberal period height	44	66.67		

* Data incomplete for one case (Case 18).

Individual profiles of growth velocity in strength are shown in Figures 158a, b, c, and d to illustrate the range of variety in timing relations which was found in our sample. (See pages 309, 310, 311.)

In relation to weight. The strength apex was somewhat more closely related to the weight apex than it was to the height apex. In one quarter of the cases (25.75 per cent) these two apexes were synchronous and 45.45 per cent occurred within .5 of a year of each other. The strength apex preceded weight in only 19.70 per cent of the cases, but the average difference was over a year (1.23 years). In over half of the cases (54.54 per cent) strength apex lagged anywhere from a half year to a year and three quarters behind weight apex. (See Table 78.)

Interrelations of apexes. In Table 79 (page 312) we have shown the timing relations of the strength apex with both weight apex and height apex.

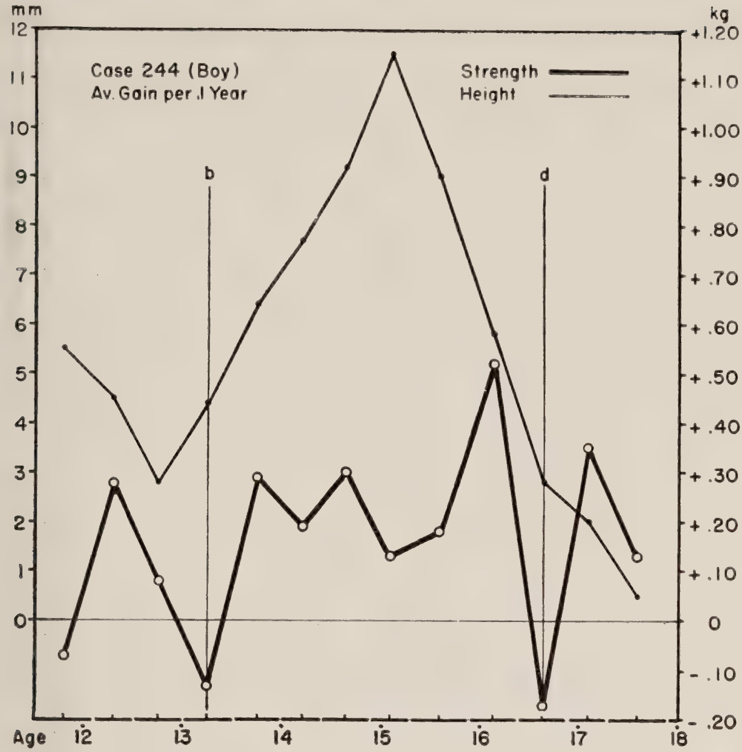


FIGURE 158b. In this case the apex velocity for strength came 1.00 year before the Case 244 illustrate the timing relationship which occurred most frequently (44.78 per cent) in our sample. Apex velocity for strength came about one year after the height apex but within the puberal growth period for height.

The outstanding fact is that in over half of the cases strength apex follows both height apex and weight apex.

The fact that many boys make maximum gains in both height and weight before they have made corresponding gains in muscular strength and coordination should be a consideration of major importance in the classification of adolescents for athletic activities.

Table 78 TIMING OF STRENGTH GROWTH APEX IN RELATION TO WEIGHT GROWTH APEX

Relation	*Number of Cases*	*Per Cent of 66 Cases**	*Years Difference* Average	Range
Apex strength synchronous with apex weight	17	25.75		
Apex strength preceding apex weight	13	19.70	1.23	.55–3.40
Apex strength following apex weight	36	54.54	1.65	.45–1.75
Apex strength within ±.5 year of apex weight	30	45.45		

* Data for Case 18 is incomplete.

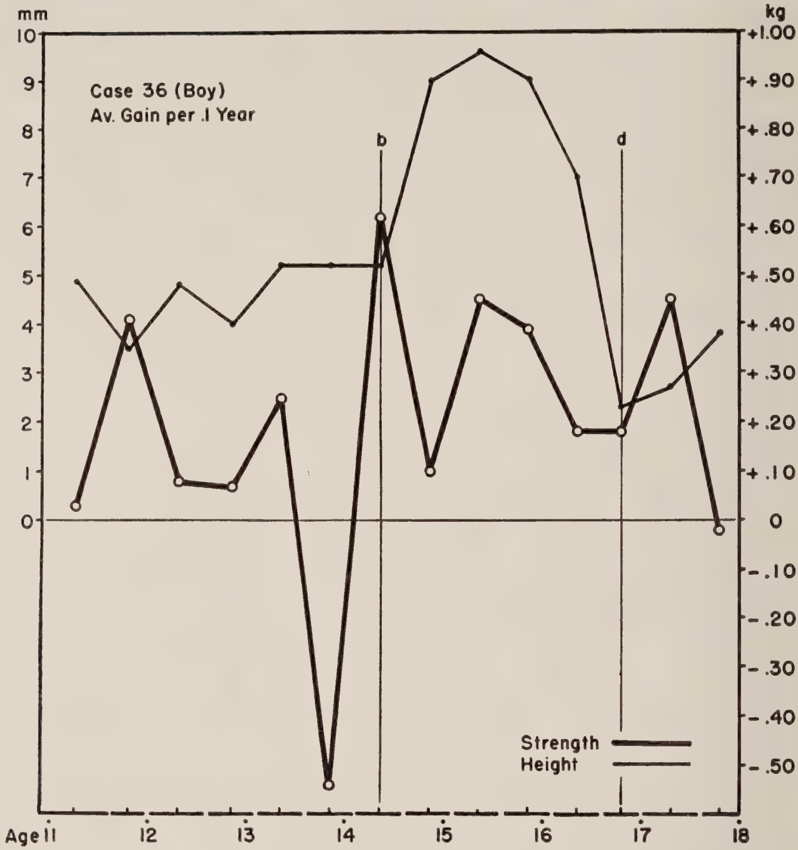


FIGURE 158b. In this case the apex velocity for strength came 1.00 year before the height apex, but within the puberal growth period for height. Only seven (10.61 per cent) of our cases showed this timing relation.

CONFIGURATION OF THE GROWTH PROFILE FOR STRENGTH

In general, the profiles of velocity change in strength growth for our sample resemble the corresponding profiles for weight and for thigh circumference more than they resemble those for the skeletal measurements. Major peaks occur at the rate of 3.21 per case, major dips at the rate of 1.65 per case.[4] Of all the measures analyzed for such peaks and dips only biacromial width and thigh circumference showed a greater average frequency for peaks, and only thigh circumference a greater average frequency for dips. Major peaks occur twice as frequently among the strength profiles as among the height profiles. The differences in profile characteristics between strength growth and height growth can be seen in Figures 158a, b, c, and d, already presented. An outstanding characteristic of many of the strength growth profiles is the frequency of alternation between acceleration and deceleration during successive six month periods. In Figures 159a, b, and c we show specimen profiles in which this peculiarity is well marked.

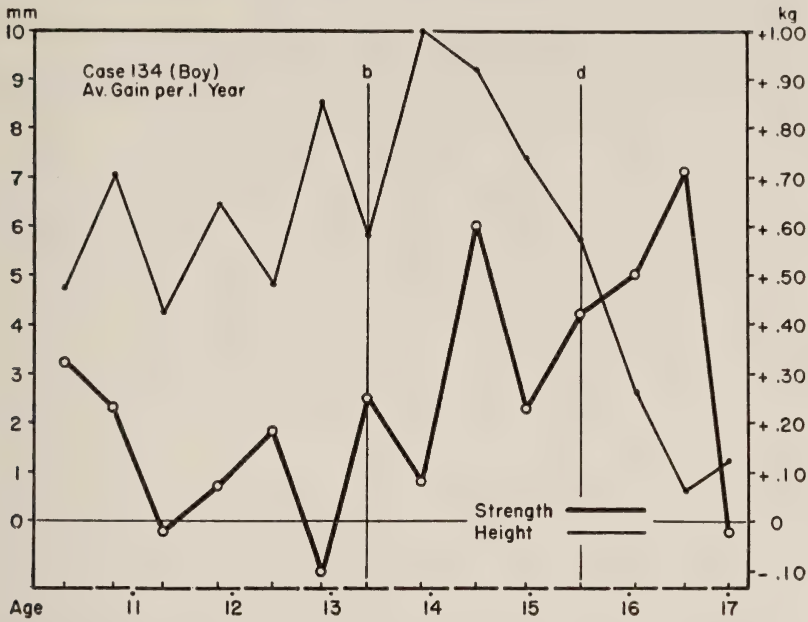


FIGURE 158c. This case serves as an example of the 21 cases (31.82 per cent) in which the apex velocity for strength growth did not occur until after the end of the puberal growth period for height. In this instance apex strength occurred 2.65 years later than apex height.

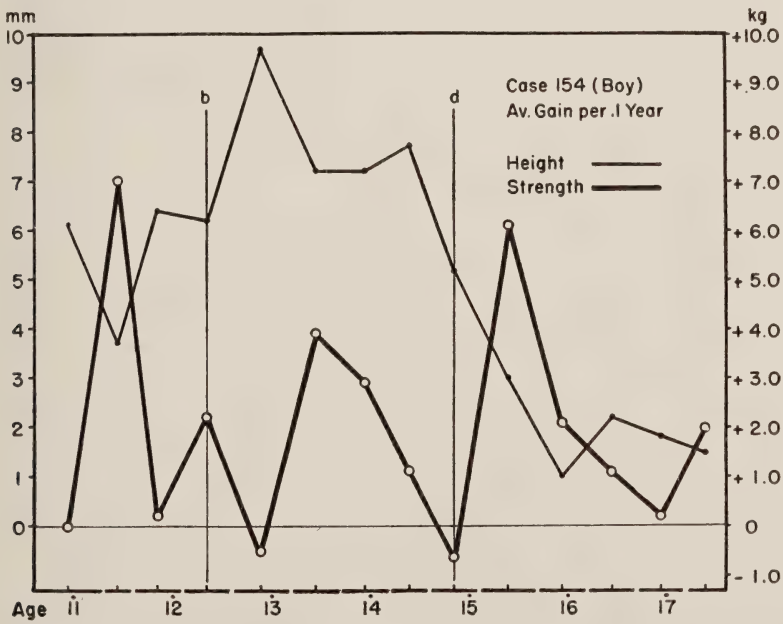


FIGURE 158d. This was the only instance from our sample where the maximum growth velocity for strength occurred before the onset of the puberal period for height. The more usual pattern of growth rhythm for strength is present following the dramatic spurt in the prepuberal period.

Table 79 TIMING RELATIONS OF STRENGTH APEX WITH HEIGHT APEX AND WEIGHT APEX—66 BOYS

		Relation of Strength Apex to Weight Apex							
		Preceding		Synchronous		Following		Total	
		Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Relation of Strength Apex to Height Apex	Preceding	5	7.57	3	4.54	0	0	8	2.12
	Synchronous	3	4.54	3	4.54	1	1.51	7	10.61
	Following	5	7.57	11	16.67	35	53.03	51	77.27
Total		13	19.70	17	25.75	36	54.54	66	100

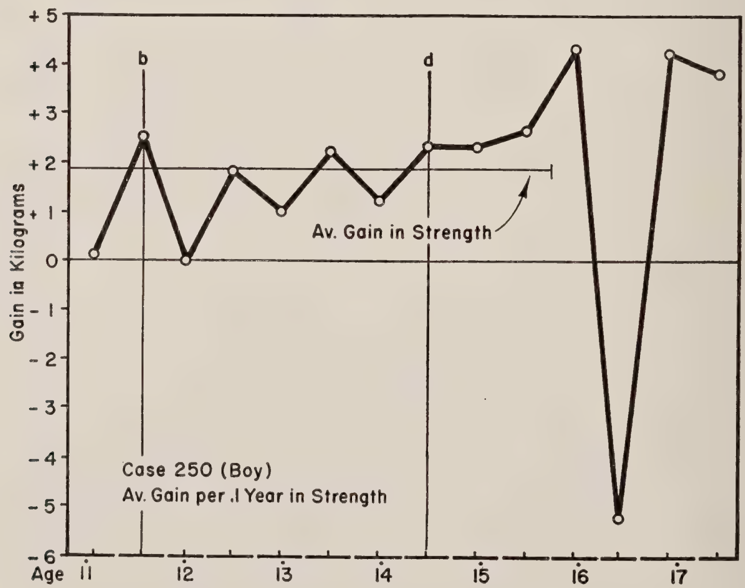


FIGURE 159a. Except during one year early in the postpuberal period this boy (Case 250) showed consistent alternation of acceleration and deceleration in strength gain throughout adolescence, but the magnitude of the fluctuations was not great. The marked loss of strength which occurred late in the postpuberal period was due to a moderately severe illness.

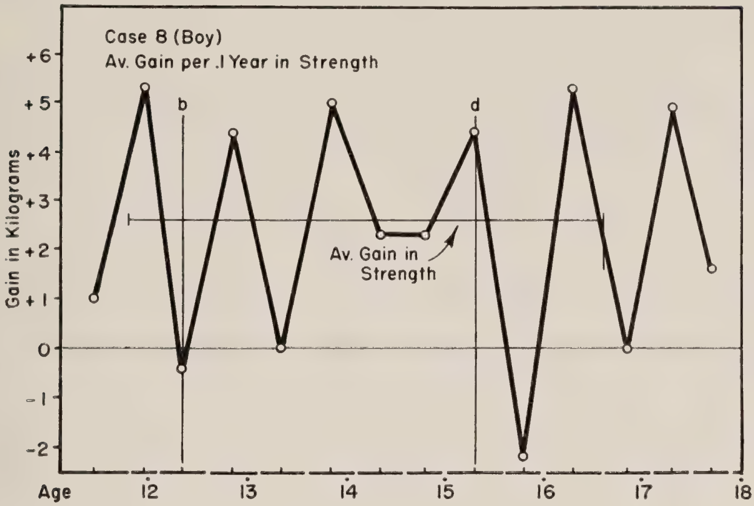


FIGURE 159b. Rhythmic alternation of above-average and below-average gains is the outstanding characteristic of this boy's strength profile. Note the magnitude of the fluctuations, with six major peaks and four major dips (Case 8).

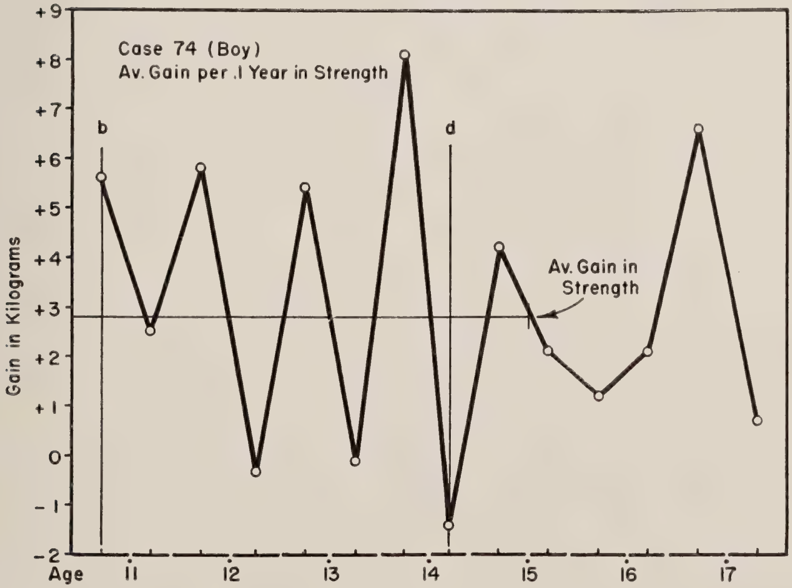


FIGURE 159c. This strength growth profile for Case 74 shows five major peaks and three major dips. During the puberal growth period for height, alternation of acceleration and deceleration was the rule, but the pattern changed in the postpuberal period.

SUMMARY

For sampling muscular strength, tests with the dynamometer were given at each examination. These tests included right hand grip, left hand grip, shoulder thrust, and shoulder pull. The sum of the four dynamometer readings was used as a composite to represent muscular strength.

Despite the several factors which might affect the reliability of such muscular test data, the profiles of growth in strength show patterns which in several respects are strikingly similar to the patterns for weight growth and for thigh circumference growth, and show definite similarity to the patterns for skeletal measures.

At Point b – 3 in the prepuberal period the group mean for muscular strength as measured was 92.95 kilograms; at Point d + 3 near the end of the postpuberal period the mean had risen to 207.12 kilograms. The range of individual variation increased at each successive stage of adolescence from 56.0 kilograms at b – 3 to 111 kilograms at d + 3. The coefficients of variation decreased at each developmental point except at the end of the puberal period. Variability was higher than for any other measure, except weight at the prepuberal and puberal onset points.

The relative strength status of individuals in the group varied markedly during the seven year period; only 10 of the 67 cases maintained the same quartile position at the four specific developmental points. The correlation between strength rating during the prepuberal and postpuberal periods was .331, P.E. ±.074. However, the correlation between strength at the onset and end of the puberal period was .678, P.E. ±.045.

The gain in strength rating during the puberal period for height ranged from 32 to 107 kilograms with a mean of 68.70 kilograms. The average yearly postpuberal gain was greater than the average yearly puberal gain. Gain in muscular strength bore a close relation to weight gain.

In two thirds of the cases apex growth for strength occurred within the puberal period for height. In all other cases except one it occurred in the postpuberal period. Apex strength followed apex height in 77.27 per cent of the cases, the average lag being 1.59 years.

In timing of apex growth, strength was more closely related to weight than to height. Apex strength and apex weight occurred synchronously in 25.75 per cent of the cases; within .5 year of each other in 45.45 per cent. Maximum increase in strength tended to follow maximum growth in weight, but in 19.70 per cent of cases the timing relation was reversed. In over half of the sample, apex growth for strength followed both apex height and apex weight.

In configuration the individual profiles of strength growth resemble

those for weight and for thigh circumference in the frequency of major peaks and dips and in the tendency toward semiannual alternation of acceleration and deceleration.

The characteristics of growth in muscular strength have important implications for the classification of adolescent boys into appropriate competitive groups in physical activities.

FOOTNOTES FOR CHAPTER XIII

[1] A description of the techniques used, with photographs, will be found on pages 28, 29, and 30 in Chapter III.

[2] The detailed tabulation by cases is shown in Appendix T.

[3] The measurements of strength were taken in kilograms. One kilogram equals 2.204 pounds.

[4] For the method used in determining these major peaks and dips in the profiles, see page 114. For complete data regarding major peaks and dips in muscular strength profiles see Appendix H.

Chapter XIV THE DEVELOPMENT OF PUBIC HAIR AND EXTERNAL GENITALIA DURING ADOLESCENCE

FOR boys, the phenomena of appropriate growth during adolescence include obvious and characteristic changes in the size of testes, penis, and scrotum. They also include changes in the length, pigmentation, and structure of hair, notably in pubic, axillary, and facial regions. Since 1904 when Crampton [1] first published the hypothesis that physiological age differed significantly from chronological age and that it could be determined by observing the stage of development shown by pubic and axillary hair, a good many attempts have been made to clarify and quantify the changes in hair and external genitalia which accompany the ripening of the procreative function.[2] From our longitudinal study we have secured data, partly by old methods and partly by new approaches, which may contribute something in this field of investigation.

At each physical examination the examiner recorded the stage of pubic and axillary hair development according to the criteria suggested by Davenport.[3]

The actual measurement of growth of glans penis, scrotum, and testes is fraught with many difficulties, physical and psychological, and was not attempted in our study. However, from our seriatim photographs it is possible to define certain specific developmental points for penis and for testes with accuracy sufficient to analyze the timing relation between these, and of these to other developmental phenomena.

In this chapter we present our findings concerning the development of pubic hair, penis, and testes in relation to developmental points in height growth. Data about axillary hair have been omitted because, for our sample, pubic hair ratings were found to be far more useful in suggesting pattern relationships.

Section A PUBIC HAIR DEVELOPMENT

The rating of pubic hair development was a routine item at each semiannual examination. The rating scale used was one in which the progressive stages begin with 0 (no differentiated pubic hair) and end with 5

(complete escutcheon of pigmented terminals over 25 millimeters long).[4] To this scale we added a rating, 6, because we found that in many cases the area of pubic hair continued to increase even after Stage 5 had been achieved. Sometimes the escutcheon extended laterally and sometimes upward along the mid-line toward the umbilicus. In Figure 160 are shown photographs which illustrate the general characteristics of the pubic hair escutcheons which correspond to the several ratings, although they do not show the specific details upon which the ratings are determined.

Since our data come from a longitudinal study of the same sample, the pubic hair ratings can be analyzed either in terms of rating achieved at a designated developmental point or more exactly by focusing attention upon the time when given ratings were *first* achieved.

PUBIC HAIR RATINGS AT DEVELOPMENTAL POINTS

In Table 80 we give a statistical summary, for our sample, of the pubic hair ratings achieved at five points related to puberal growth in height.[5]

Table 80 PUBIC HAIR RATINGS RELATED TO PUBERAL GROWTH IN HEIGHT—67 BOYS

	b − 3		b		c		d		d + 3	
Pubic Hair Rating	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
0	2	2.98								
1	49	73.13	35	52.24	3	4.48				
2	13	19.41	27	40.30	8	11.93				
3	3	4.48	5	7.46	30	44.78				
4					23	34.33	16	23.88		
5					3	4.48	47	70.15	33	49.25
6							4	5.97	34	50.75
Total cases	67	100.00	67	100.00	67	100.00	67	100.00	67	100.00

It will be noted that at b — 3, approximately 1.25 years before the onset of the puberal period for height, 73.13 per cent of our 67 cases rated 1 in pubic hair development, but that the range of ratings was from 0 to 3. At the onset of the puberal period (b) the number of cases rating 2 had doubled and the range had decreased (1 to 3). At Point c, halfway through the puberal period, the range included all ratings except 0 and 6 with 79.11 per cent of the cases rated 3 or 4. By the end of the puberal period (d) the range of distribution had decreased sharply, 94.03 per cent of the cases being rated 4 or 5. At Point d + 3 in the postpuberal period the ratings were almost equally divided between 5 and 6. On the original Davenport scale all would have been rated 5.

In Table 81 the same data are analyzed according to central tendencies. The striking increase in the mean during the puberal period indicates the

Rating 0

No differentiated pubic hair.

Rating 1

Unpigmented down, 2 to 3 millimeters long (not visible in photograph).

Rating 2

Slightly pigmented down. Sparse semi-terminals 4 to 10 millimeters long (not visible in photograph).

Rating 3

Sparse, pigmented, usually wavy terminals. Not over 25 millimeters long.

FIGURE 160.

Rating 4

Terminals. Same as Rating 3, only full density.

Rating 5

Fully developed, dense, frequently curly hair, over 25 millimeters long.

Rating 6

Extension of the fully developed hair, laterally and upward.

FIGURE 160. This series of photographs for one boy (Case 110) shows the general appearance of the pubic area at the several stages of pubic hair development described by Davenport. Unfortunately, the photographic technique did not record the changes in length and color of the vellus growth of Stages 1 and 2 nor the scattered growth of pigmented semi-terminals at Stage 3 as clearly as they were seen by the examiner.

strong tendency for rapid pubic hair development to coincide with rapid growth in height.

Relation of chronological age and pubic hair ratings at developmental points. There was very little relation between a boy's chronological age and his pubic hair rating at the onset of the puberal period, (r. 228, P.E. ±.078). This relation increased, however, to a correlation of .422, P.E. ±.068 at the end of the puberal period.

Table 81 PUBIC HAIR RATINGS AT FIVE DEVELOPMENTAL POINTS RELATED TO THE PUBERAL GROWTH PERIOD FOR HEIGHT—67 BOYS

	Range	*Mean*	*Standard Deviation*	*Median*	Q_1	Q_3
Prepuberal (b − 3)	0 –3.00	1.14	.575	1.17	1.08	1.64
Onset of puberal period (b)	1.00–3.25	1.83	.706	1.73	1.16	2.44
Midpoint puberal period (c)	1.40–5.00	3.64	.795	3.67	3.13	4.16
End puberal period (d)	4.00–6.00	5.04	.443	5.09	5.00	5.19
Postpuberal (d + 3)	5.00–6.00	5.50	.500	5.55	—	—
Puberal gain (b − d)	1.50–4.50	3.31	.764	3.29	2.66	4.06

Relation of pubic hair ratings at onset and end of puberal period. As the initial step in attempting to find out what other variables in development might be related to variations in pubic hair growth, we have tabulated our cases according to pubic hair rating at onset (b) and end (d) of the puberal period for height, as shown in Table 82.

From this table we see that the most usual pattern of change (23 boys, 34.33 per cent) was from Rating 1 at b to Rating 5 at d; the next most frequent was from Rating 2 to Rating 5 (19 boys, 28.36 per cent). These two very similar patterns account for 42 cases (62.69 per cent). The coefficient of correlation between pubic hair rating at onset and end of the puberal period for height was .181, P.E. .079, indicating that the boys who made a low rating at b did not necessarily make a low rating at d. This can readily be seen in Table 82. In fact, there was a strong tendency for a boy to reach Rating 5 by the end of the puberal period, no matter what his rating had been at the onset.

Patterns which deviated most markedly were those of Cases 130, 218, 220, and 224 whose pubic hair was unusually well developed at the end of the puberal period.

Case 224 was markedly different from his peers during the prepuberal period, with excessive fatty tissue and accelerated development in shoulder width, hip width, and leg length. During the puberal period his growth showed progressively fewer anomalies. His photographs will be found in Figure 107b on page 185, and his height profile in Figure 91a on page 156.

Table 82 PUBIC HAIR RATINGS AT ONSET AND END OF PUBERAL PERIOD FOR HEIGHT—67 BOYS BY CASE NUMBERS

Pubic Hair Rating at End Puberal Period	*Pubic Hair Rating at Onset Puberal Period* 1	2	3	Total Number of Cases
4	(11) 66 134 144 184 212 206 72 88 112 34 304	(5) 176 32 40 50 242		16
5	(23) 62 146 244 58 116 216 78 36 52 108 180 106 294 30 82 166 26 168 10 74 150 250 120	(19) 104 86 100 110 136 234 292 230 104 18 24 44 64 8 60 80 92 154 190	(5) 54 68 84 96 236	47
6	(1) 220	(3) 218 130 224		4
Total Number of Cases	35	27	5	67

Cases 130, 218, and 220 were all late in beginning and in ending their puberal height growth. Case 130 reached Point d in height at 17.5 years; during the whole of his puberal period his dental development and bone age ratings were precocious. Both Case 218 and Case 220 completed the puberal period at approximately 17.0 years, and both were somewhat precocious in bone age as rated from X-ray photographs. From these four cases we may tentatively suggest that marked variation from the majority pattern of pubic hair development tends to be associated with anomalies of skeletal development, with unusually rapid development in height and breadth during the prepuberal period, and sometimes with marked obesity.

We may conclude, therefore, that while the period of rapid development for pubic hair strongly tends to coincide with the period of rapid development in height, an individual's pattern of pubic hair changes cannot be taken, by itself, as an accurate index of other aspects of growth.

PUBERAL GAIN IN PUBIC HAIR RATINGS

The actual gains made in pubic hair ratings by the 67 boys from the onset to the end of the puberal period are shown in Table 83. From these data it is obvious that the pattern of pubic hair development varies widely among individual boys during the puberal growth period for height. One boy made a gain of only 1.5 on the rating scale, while another made a gain of 5.0. A gain of 2 points was made by 34.32 per cent, a gain of 3 points by 31.34 per cent, and a gain of 4 points by 29.85 per cent. The mean gain was over 3 points on the rating scale with an interquartile range of 1.4 points. (See Table 81, page 318.)

Table 83 PUBERAL GAINS IN PUBIC HAIR RATINGS

Gain in points	1	2	3	4	5
Per cent of 67 cases	2.98	34.32	31.34	29.85	1.49

The growth in pubic hair rating during the puberal period was not distributed evenly during the whole period for all boys. We analyzed what percentage of the total puberal gain occurred during the first half of the puberal period and found it varied from 10 per cent to 100 per cent. The mean was 58.61 per cent; S.D., 19.45 per cent. The median was 61.25 per cent with 50 per cent of the cases occurring between 45.75 per cent and 68.91 per cent. Forty out of the 67 boys (59.70 per cent) made more than half of their puberal gain in pubic hair rating during the first half of the puberal period.

The amount of puberal gain in pubic hair development was positively related to the duration of the puberal period (r .349, P.E. $\pm$.072) though not as highly as for other measures previously reported.

Rate of puberal change in pubic hair rating.[6] The boys showed wide variation in the rate of gain during the puberal period, Case 68 gaining on the average a fourth of a point every six months and Case 146 gaining at the rate of 1 point every six months. Fifty-one cases (76.05 per cent) made a gain on the average of .4, .5, or .6 of a point every six months. (See Table 84.) The mean was .57 point (S.D. .156 point), median .59 point, with 50 per cent of the cases gaining at the rate of .51 to .67 point per six months.

The coefficient of correlation between rate of pubic hair gain and rate

Table 84 RATE OF CHANGE IN PUBIC HAIR RATING DURING PUBERAL GROWTH PERIOD

Average Points Gain Per .5 Year	*Number of Cases*	*Per Cent of 67 Cases*
.20	1	1.49
.30	3	4.48
.40	11	16.42
.50	21	31.34
.60	19	28.36
.70	1	1.49
.80	9	13.43
.90	1	1.49
1.00	1	1.49

of height gain during the puberal period was .226 $\pm$.079, which indicates the lack of significant relationship between these two phenomena of adolescent growth.

TIME OF FIRST APPEARANCE OF SPECIFIC PUBIC HAIR RATINGS

Thus far we have been discussing the relation between established developmental points in height growth and pubic hair ratings as recorded at those points regardless of when those ratings first appeared. Thus, two cases may be rated 2 in pubic hair at the puberal onset for height, but one of them may have achieved that rating a year earlier and then remained at the same stage for two examinations, while the other case achieved Rating 2 for the first time at the puberal onset.

Obviously, such a distinction can be made only when serial ratings are available. The reader may wonder why we stress such a seemingly academic consideration. We do so because our experience leads us to believe that spot appraisals of pubic hair development have sometimes been accepted in cross-sectional studies of growth as indices of maturity without the realization that the same pubic hair rating might have been obtained earlier or later.

At the beginning of our study 9 boys had a pubic hair rating of 0; 46 boys had a rating of 1; 11 boys had a rating of 2; and 1 boy had a rating of 3. It was not possible, therefore, to ascertain for our sample when Rating 1 was first achieved.

Records of the time when Rating 2 in pubic hair (slightly pigmented down with sparse semi-terminals) was reached were available for 55 boys. The timing varied from 2.25 years preceding to 2.00 years following onset of the puberal growth period for height.[7] (See Table 85.) About one third of the cases (32.72 per cent) received Rating 2 for the first time

at the examination immediately preceding or following puberal onset for height. The twelve boys not included in Table 85 all received their first Rating 2 sometime before puberal onset.[8] However, even if these twelve boys are included, we find that a higher percentage of cases reached Rating 2 after puberal onset than before (39.39 per cent after onset compared with 31.81 per cent before).

Of the 28 cases who had a pubic hair rating of 2 at the puberal onset, one third received this rating for the first time at the examination immediately preceding the onset (approximately .25 year). The remaining two thirds gained their first Rating 2 from .5 year to 2.45 years preceding the puberal onset.[9]

Table 85 INITIAL PUBIC HAIR RATING 2 IN RELATION TO ONSET PUBERAL GROWTH PERIOD FOR HEIGHT—55 BOYS

Years from Onset Puberal Period for Height	*Pubic Hair Rating 2* Number of Cases	Per Cent of Cases
Preceding:		
2.00–2.49	1	1.82
1.50–1.99	0	—
1.00–1.49	4	7.27
1.50– .99	6	10.91
.25– .49	9	16.36
Following:		
.25– .49	10	18.18
.50– .99	14	25.46
1.00–1.49	9	16.36
1.50–1.99	1	1.82
2.00–2.49	1	1.82
Total	55	100.00

Maturity in pubic hair development by the Davenport scale (Rating 5) was first reached by 52.24 per cent of the 67 boys at the examination immediately preceding or following the end of the puberal period for height. Of the remaining cases 37.31 per cent occurred before and 10.45 per cent after this time. The occurrence ranged from 1.30 years before to 1.30 years after the puberal end (Table 86).

The median case reached Rating 5 at .17 year preceding the end of the puberal period, with fifty per cent of the cases occurring between .45 year before to .37 year after the end of the puberal period. There were only 6 cases out of the 67 boys (8.95 per cent) who had not reached Rating 5 by six months after the end of the puberal growth period for height.

Of the fifty cases who were rated 5, or better, in pubic hair at the end

of the puberal period, 46 per cent received Rating 5 for the first time at the examination immediately preceding the end of the puberal period. The remaining 54 per cent received their first rating of mature pubic hair from .5 year to 1.30 years preceding the puberal end.

Table 86 MATURITY IN PUBIC HAIR RATING IN RELATION TO PUBERAL PERIOD FOR HEIGHT—67 BOYS

Years from End Puberal Period for Height	*Davenport Rating 5*		*Stolz Rating 6*	
	Number of Cases	Per Cent of Cases	Number of Cases	Per Cent of Cases
Preceding:				
1.00–1.49	14	20.89		
.50– .99	13	19.40	1	1.49
.25– .49	20	29.85	3	4.48
Synchronous:	3	4.48	0	—
Following:				
.25– .49	11	16.42	4	5.97
.50– .99	4	5.97	14	20.89
1.00–1.49	2	2.98	10	14.92
1.50–1.99			18	26.86
2.00–2.49			11	16.42
2.50–2.99			5	7.46
3.00–3.49			1	1.49
	67		67	

Whereas mature pubic hair by the Davenport scale was in general an accomplishment of the second half of the puberal period for height, the extension of the pattern of pubic hair (Rating 6) was a growth phenomenon of the postpuberal period. Only four boys (5.97 per cent) had reached this stage before the end of the puberal period, and three of these occurred at the examination immediately preceding the end (Table 86). The median case reached Rating 6, 1.55 years after the end of the puberal period, fifty per cent of the cases occurring between .81 year and 2.01 years following the puberal end. The total range for the 67 boys was from .75 year preceding puberal end (Case 130) to 3.25 years following (Case 86).

The coefficient of correlation between chronological age at the end of the puberal period for height and at Rating 6 in pubic hair was .30, P.E.±.075, indicating a slight but positive tendency for these phenomena to occur in regular sequence.

TEMPO OF CHANGE IN PUBIC HAIR DEVELOPMENT

There was wide variation in the length of time it took a boy to develop from one pubic hair rating to the next. In Table 87 we have shown the

Table 87 DURATION OF PUBIC HAIR RATINGS—NUMBER OF SEMI-ANNUAL EXAMINATIONS—67 BOYS

Duration Rating	*Pubic Hair Ratings* 1		2		3		4		5	
Number of Examinations	Number of Cases	Per Cent	Number of Cases	Per Cent	Number of Cases	Per Cent	Number of Cases	Per Cent	Number of Cases	Per Cent
0			5	7.57	14	20.89	8	11.94	4	5.97
1	6	10.91	25	37.87	30	44.78	26	38.80	8	11.94
2	11	20.00	12	18.18	13	19.40	21	31.34	11	16.42
3	13	23.64	11	16.67	7	10.45	9	13.43	11	16.42
4	6	10.91	6	9.24	0		2	2.98	16	23.88
5	6	10.91	2	3.33	3	4.48	1	1.49	7	10.45
6	1	1.82	1	1.51					6	8.95
7	7	12.72							2	2.98
8	3	5.45							2	2.98
9	2	3.64							1	1.49
	55*	100.00	66†	100.00	67	100.00	67	100.00	67	100.00

* Forty-six of these cases had pubic hair Rating 1 at the first examination so that the duration recorded is minimum.

† One case not included because he received Rating 3 at beginning of study; 12 of the 66 cases received pubic hair Rating 2 at the first examination so that the duration recorded for them is minimum.

duration of each level of development by giving the number of cases which had each rating for one or more examinations. In each instance the maximum number of examinations for which a case received the specific rating is given.

There were 23 boys who skipped one rating and 4 boys who skipped two noncontiguous ratings in the series. (See column 0 examinations in Table 87.) This probably means that development from one level to the next took place so rapidly that the six month interval between examinations was too long at certain times to catch all stages of development.

We have included Rating 1 in Table 87, even though, for 46 out of the 55 cases reported, the duration of the level of development is minimum.[10] For the 9 boys for whom the records are complete on Rating 1, duration varied from six months to three and one-half years. The addition of the other 46 cases extends this variation to four and one-half years. It might be even longer if our records were complete. The two boys who had Rating 1 for nine examinations were quite different in developmental patterns. Case 220 had a long prepuberal period and changed from Rating 1 to Rating 3 in the six months before the middle of the puberal period. Case 166, on the other hand, had a relatively short prepuberal period. He continued to have Rating 1 until past the middle of the puberal period when he made a rapid change to Rating 3 in less than six months. Both boys had a high mesomorphic component by Sheldon's somatotyping. Case 92, for whom we have complete data and who remained at Rating 1 for only one examination, made rapid concentrated

growth in other aspects of development.[11] He was near the third quartile in age at puberal onset and had a high ectomorphic component by Sheldon's ratings.

Approximately 45 per cent of our cases remained at the level of slightly pigmented down with sparse semi-terminals (Rating 2) for a period of six months or less. The other boys remained at this level for varying lengths of time, the longest time being three years. The boy with the longest duration for Rating 2, Case 130, was the latest developer in our sample with a long prepuberal period. However, he was one of the four boys who reached Rating 6 in the latter half of the puberal period.

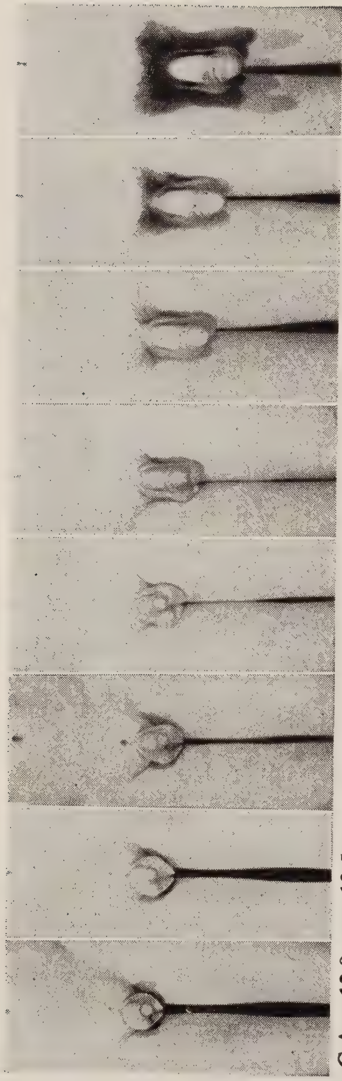
The tendency to move from Stage 3 in pubic hair rating to Stage 4 in a period of six months or less was more marked, including about two thirds of the 67 boys. Pubic hair Rating 3 lasted 2.5 years for three boys, with the possibility that it was even longer for Case 96 who rated 3 at the first examination.

Growth from full density terminals (Rating 4) to Davenport's rating of maturity (Rating 5) took six months or less for 50.74 per cent of the 67 boys, but one boy (Case 72) took 2.5 years to accomplish this development. This boy had Rating 4 from the middle of the puberal period until a year after the end of the period. He had a longer than average, undramatic puberal period.

The length of time which the 67 boys remained at Davenport's rating of full pubic hair maturity (Rating 5) showed as wide variation as the time they remained at Rating 1. About three fourths (74.63 per cent) received Rating 5 for a period of two years or less, but one boy (Case 86) took four and one-half years before the fully developed pubic hair had extended its pattern laterally and upward. This boy achieved Rating 5 just after midpoint of the puberal period and continued on this level for more than three years after the end of the puberal period.

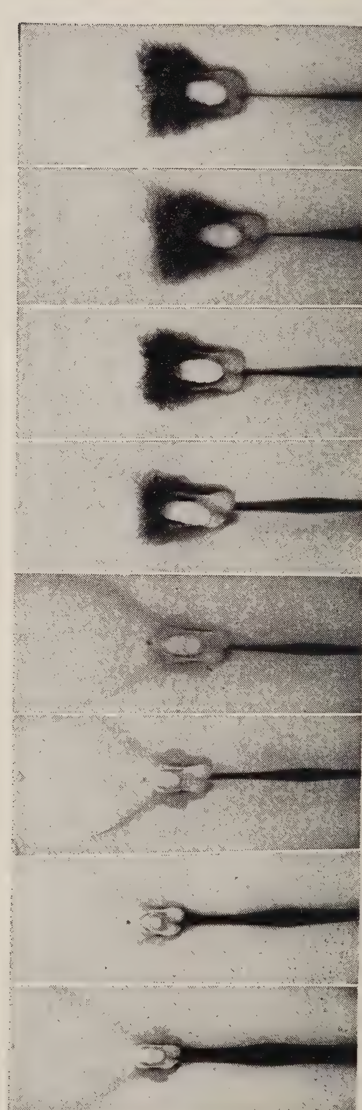
Section B GROWTH OF THE GLANS PENIS

The growth which takes place in the penis during childhood is very gradual. During the puberal period, however, development is accelerated and glans penis growth is of a different order. There is a general development not only in length and breadth of the shaft but in the size of the glans penis in relation to the whole organ. The rapid development of the glans penis is a characteristic feature of puberal development.[12] From the photographic records it is easily apparent that a period of rapid increase in the circumference of the glans penis took place in each of the 67 boys, and that this period of rapid increase occurred with a rather definite timing relation to the puberal growth period for height.



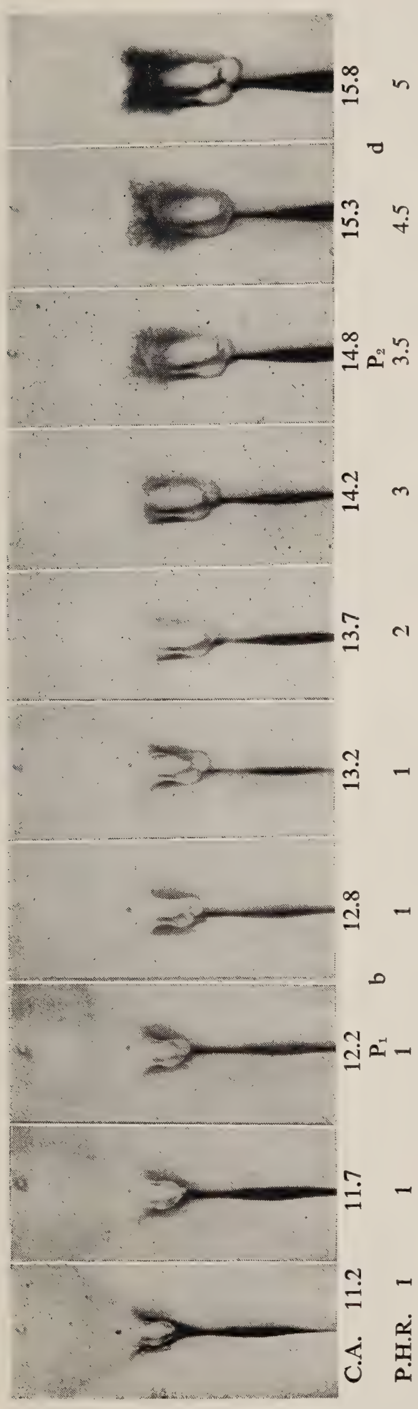
C.A.	12.9	13.5	14.0	14.5	14.9	15.5	15.9	16.5
		b	P_1				P_2	d
P.H.R.	1	1	1	1	2	3	4	4

Case 30

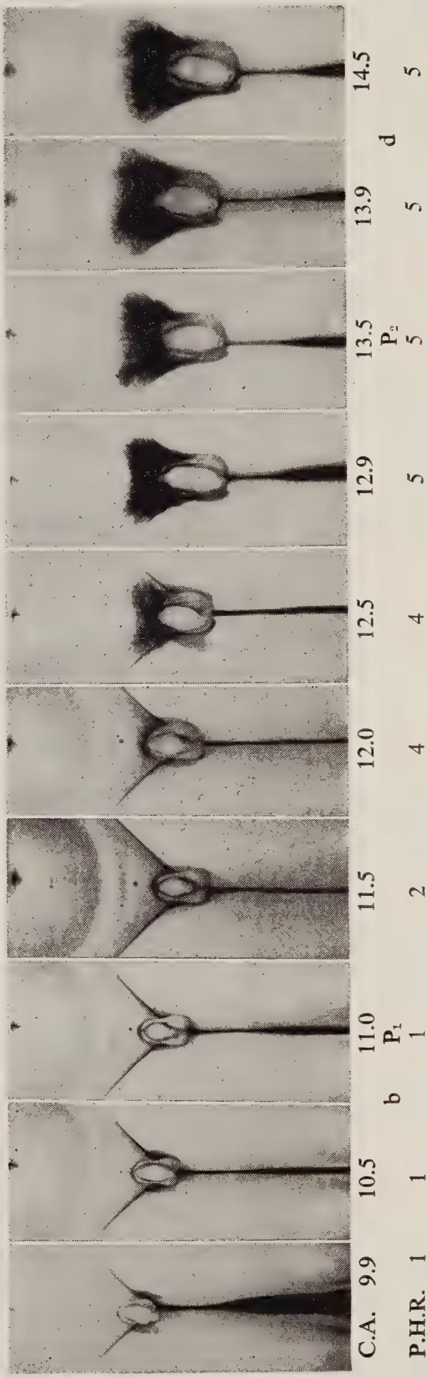


C.A.	11.6	12.0	12.6	13.00	13.6	14.1	14.6	15.0
		b	P_1			P_2	d	
P.H.R.	2	2	2	2	4	5	5	5

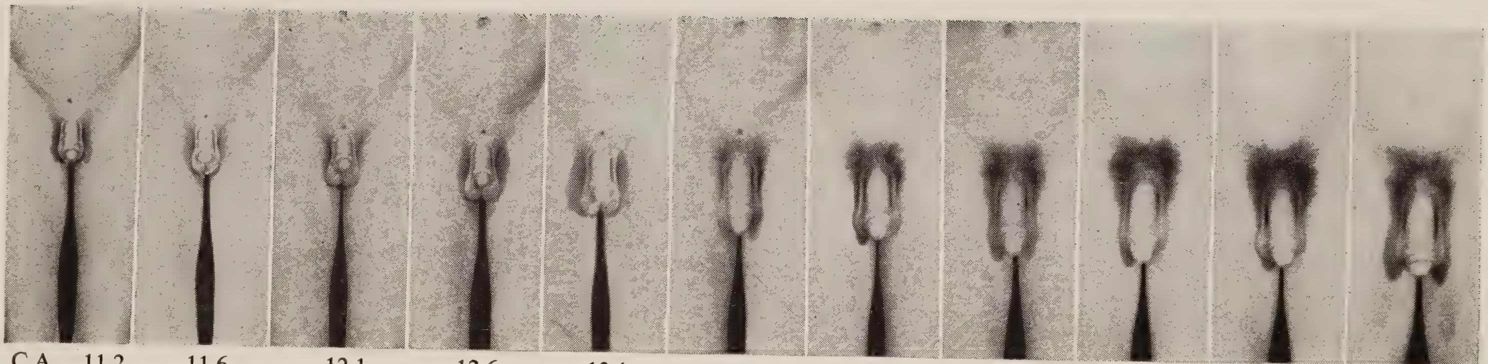
Case 80



Case 212



Case 216



C.A.	11.2	11.6	12.1		12.6	13.1	13.6	14.2	14.7	15.2	15.7		16.2
			P_1	b						P_2		d	
P.H.R.	1	1	2		2	3	3	4	5	5	5		5

Case 230

FIGURE 161. Photographic series of genitalia for five boys. For each case the onset (b) and end (d) of the puberal growth period for height are indicated, also the onset (P_1) and end (P_2) of the accelerated growth for glans penis. These cases illustrate the rapid increase in the circumference of the glans penis which occurs between P_1 and P_2 and which determines those points. Note the consistent timing relation of P_1 to b and of P_2 to d. This close relation was characteristic for our sample. Pubic hair ratings (P.H.R.) have been given beneath the photographs for comparison.

The points in each photographic series at which the onset and cessation of obvious growth acceleration of glans penis occurred were determined by repeated ratings by three persons independently.[13] The point of onset of obvious growth of glans penis we have designated "P_1," and the point of cession of obvious growth "P_2." The point at which the puberal growth spurt for glans penis ceases (P_2) is not quite so clearly evident in the photographs as the point of onset. In Figure 161 we have attempted to illustrate the criteria by which points P_1 and P_2 were determined.[14]

AGE AT TIME OF ACCELERATION AND DECELERATION OF GLANS PENIS GROWTH

In Figures 162 and 163 we show the distribution of our 67 cases in terms of the chronological ages at which P_1 and P_2 occurred. The range for Point P_1 was from 11.0 to 14.4 years; that for Point P_2 was from 13.5 to 16.6 years. The age range for P_2 is .3 year less than for P_1. The mean ages were 12.68 years and 15.02 years, respectively. Considering the number of cases, the distribution patterns are quite symmetrical.

							294											
							234											
							136											
							96		236									
							60		176				92					
					146		250	168	134				66					
					72	230	242	116	120	292	224	180		220				
				150	88	184	212	18	80	304	166	62		84		78		
	216		104	110	32	154	164	112	44	206	68	54	244	50	190	58		130
	74	108	144	100	26	82	86	64	8	106	40	10	24	36	52	30	218	34
Chronological age years	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.2	14.4

FIGURE 162. Distribution of 67 boys by case numbers according to chronological age at the onset (P_1) of the period of accelerated growth of the glans penis: mean, 12.68 years; standard deviation, .823 year; median, 12.64 years; Q_1, 12.19 years; Q_3, 13.31 years.

										206							
										180							
							134	292		164							
							100	106	168	66							
							18	72	112	236	24		244	58			
				184	96		154	64	54	230	304		92	50			
			108	80	110	146	150	60	10	224	294		52	36			
	216		26	144	86	116	120	242	40	176	234	84	34	190	130		
	104	250	88	74	82	32	44	212	8	62	136	166	30	68	220	218	78
Chronological age years	13.4	13.6	13.8	14.0	14.2	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6

FIGURE 163. Distribution of 67 boys by case numbers according to chronological age at the end (P_2) of the period of accelerated growth of the glans penis: mean, 15.02 years; standard deviation, .752 year; median, 15.08 years; Q_1, 14.58 years; Q_3, 15.57 years.

These data are summarized in Table 88, showing the percentage of cases which reached P_1 and P_2 at different ages. This table brings out the overlapping of ages for P_1 and P_2, 15 boys reaching P_2 when other boys had not yet begun or were just beginning the puberal spurt in glans penis growth.

Table 88 CHRONOLOGICAL AGE OF 67 BOYS AT POINTS OF ACCELERATION (P_1) AND DECELERATION (P_2) IN GROWTH OF GLANS PENIS

	P_1		P_2	
C.A.	Number of Cases	Per Cent	Number of Cases	Per Cent
11.0–11.49	3	4.49		
11.5–11.99	10	14.92		
12.0–12.49	16	23.88		
12.5–12.99	14	20.89		
13.0–13.49	11	16.42		
13.5–13.99	7	10.45	6	8.95
14.0–14.49	6	8.95	9	13.44
14.5–14.99			16	23.88
15.0–15.49			19	28.36
15.5–15.99			8	11.94
16.0–16.49			8	11.94
16.5–16.99			1	1.49
	67	100.00	67	100.00

The coefficient of correlation between the chronological age at onset and end of accelerated growth of penis was .847, P.E.±.023.

TIMING RELATIONS OF PERIOD OF ACCELERATED GROWTH OF GLANS PENIS AND PUBERAL PERIOD FOR HEIGHT

Onset of accelerated growth. There was a marked tendency toward synchrony in the occurrence of puberal acceleration in glans penis growth and height growth. Since P_1 was rated for a photograph taken at the time of examination while b was determined by definition at a point midway between two examinations, no case can show complete synchrony. However, the close timing relation between P_1 and b is clearly shown in Table 89. About four fifths of the 67 boys (79.10 per cent) showed the beginnings of accelerated glans penis growth at the examination immediately preceding or following the onset of accelerated growth in height (b). The mean of the differences between the age at the onset of the puberal period for height and the age at the beginning of the accelerated growth for glans penis was only .07 of a year.

The coefficient of correlation between these two phenomena of accelerated puberal growth was .866, P.E.±.021, indicating a close relationship in timing.

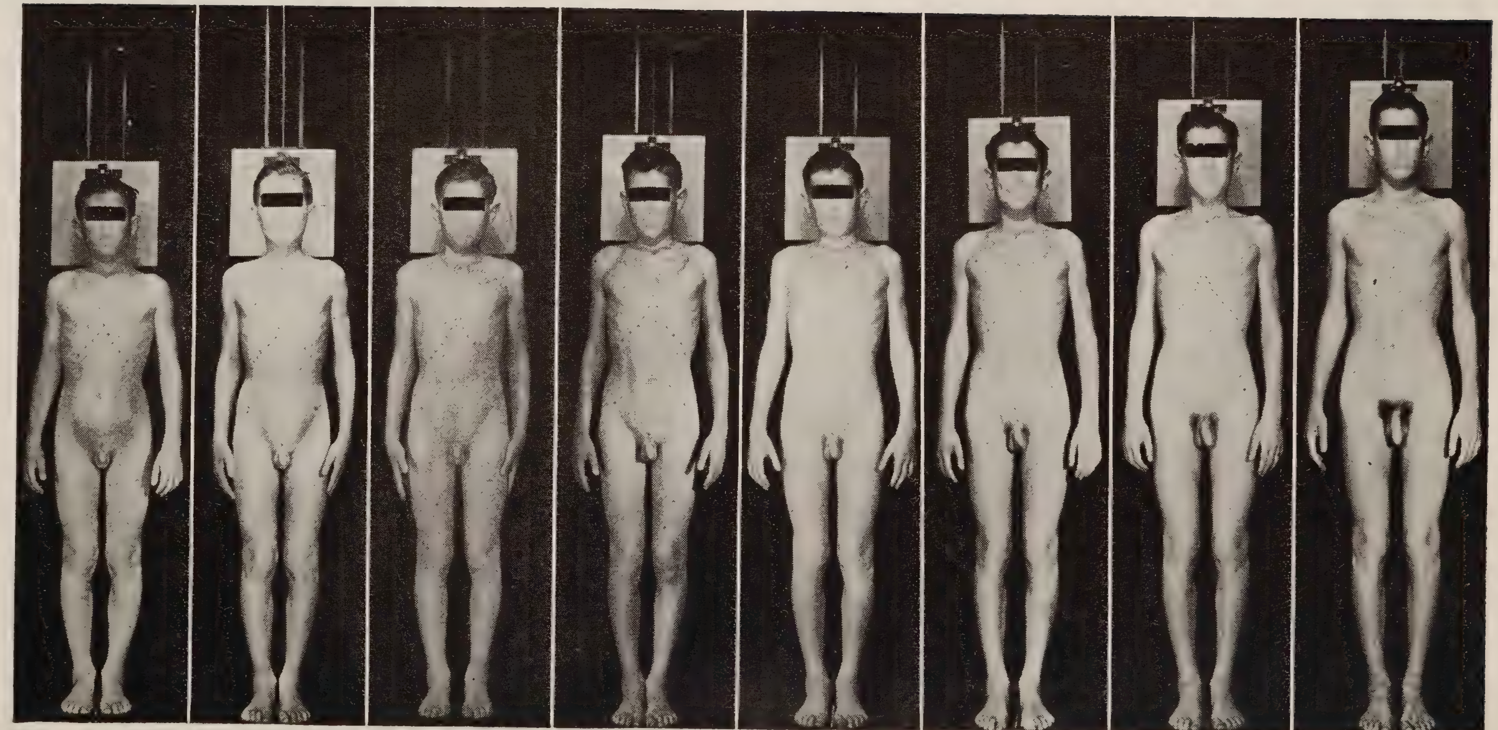
Table 89 RELATION OF ONSET OF ACCELERATED GROWTH PERIOD FOR GLANS PENIS TO ONSET OF PUBERAL GROWTH PERIOD FOR HEIGHT—67 BOYS

	Number of Cases	*Per Cent of 67*	*Range in Years*
Onset for glans penis preceding onset for height	37	55.22	.20–.80
At first examination preceding height onset	28	41.79	.20–.35
At second examination preceding height onset	9	13.43	.65–.80
Onset for glans penis following onset for height	30	44.78	.20–.80
At first examination following height onset	25	37.31	.20–.35
At second examination following height onset	5	7.46	.65–.80
Onset for glans penis within one examination before or after onset height	53	79.10	

In Figure 164 are shown the photographs of three boys, in two of whom the onset of acceleration in glans penis growth occurred at about the same time as the onset of accelerated height growth (Case 136 and Case 116); in the third, P_1 occurred .80 year before b (Case 24). Of the five boys who showed a pattern of lag in glans penis development, four were in a fat period; of the ten boys who were correspondingly precocious in glans penis development, two were in an increased fat period.

End of accelerated growth. The end of the accelerated growth period for glans penis preceded the end of the puberal period for height in all but 6 of the 67 boys. The data regarding the timing relation of the end of accelerated glans penis growth and end of puberal height growth are summarized in Table 90.

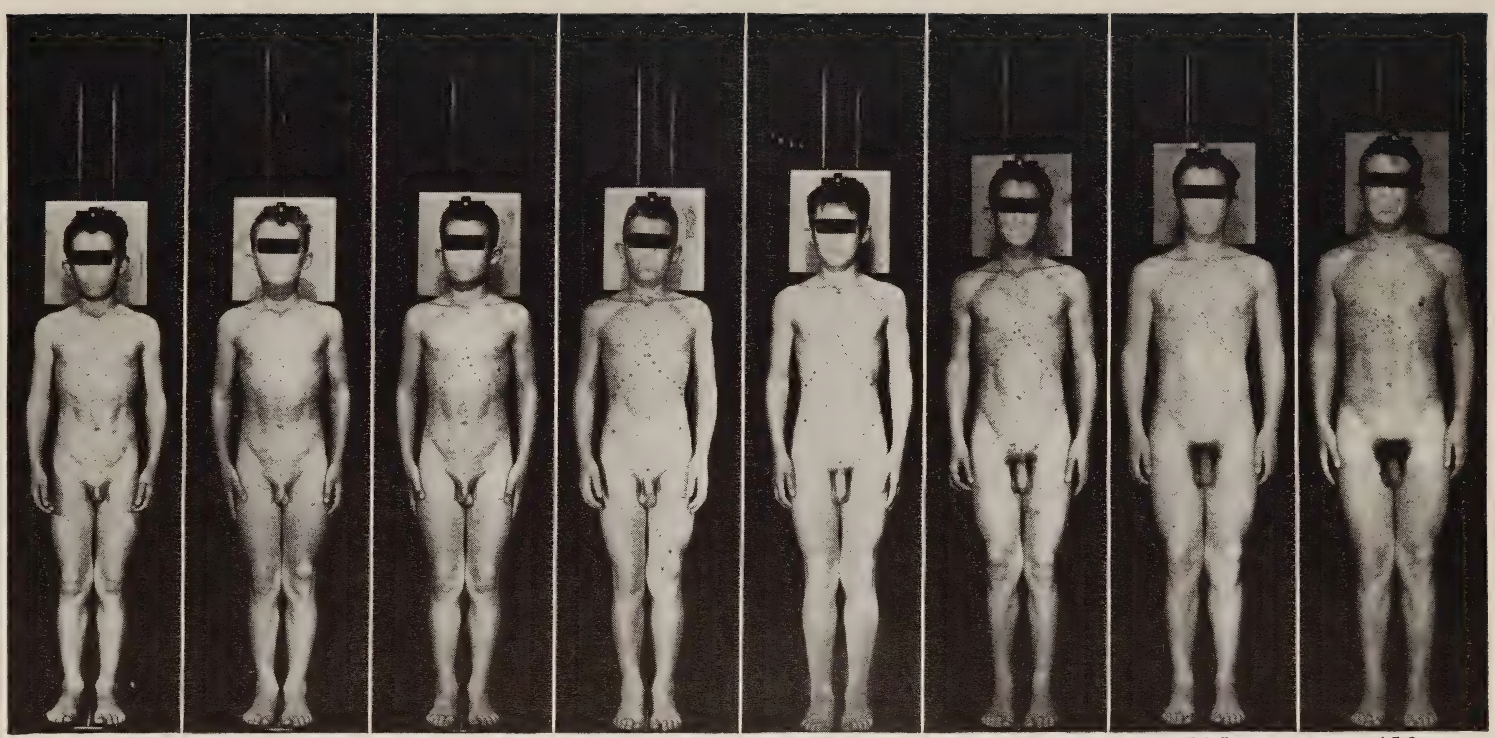
For 58 of the boys (86.57 per cent) P_2 occurred at the first or second examination preceding d. Sometime within nine months of the time when the puberal period for height ended, therefore, most of the boys completed their period of rapid growth of glans penis. These 58 cases were evenly grouped around a half year preceding d. The mean of the differences between the chronological age one half year before the end of the puberal period for height and the age at the end of the accelerated growth of glans penis was .03 year. The coefficient of correlation between age at P_2 and age at d was .888, P.E. $\pm$.017.



C.A. 11.3 | 11.8 | 12.3 P_1 | b | 13.0 | 13.4 | 13.9 | 14.4 | 14.9

Case 136

FIGURE 164.

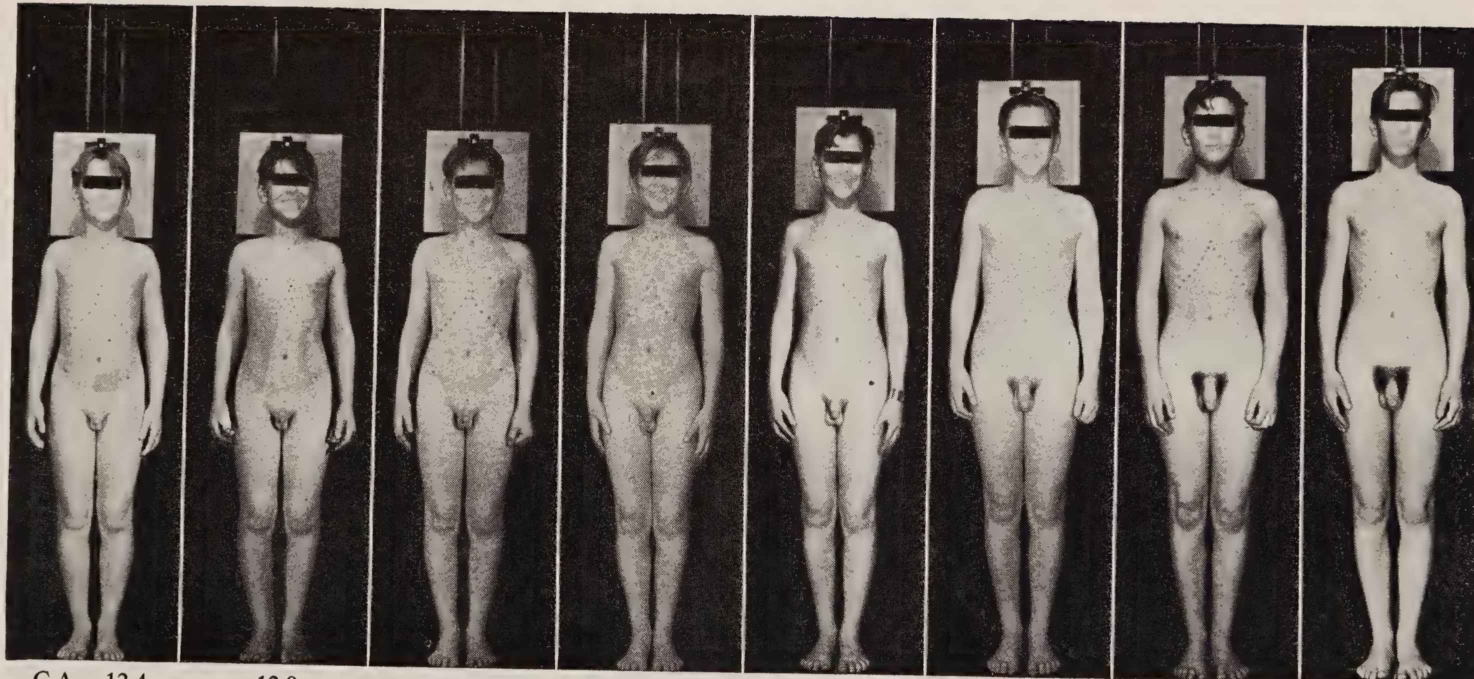


C.A. 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0

b P_1

Case 116

FIGURE 164.



Case 24

FIGURE 164. The usual close timing relations between the onset of the puberal spurt in glans penis growth (P_1) and the onset of the puberal growth period for height (b) is illustrated by Cases 136 and 116. The extreme (among our sample) of precocity in the onset of puberal growth in glans penis in relation to the onset of the puberal growth period for height is illustrated by Case 24. In Cases 136 and 116, P_1 and b occurred within the same month period. In Case 24, P_1 preceded b by .8 year.

The series of photographs of three boys in Figure 165 illustrates different timing relations of the end of the accelerated growth in glans penis with that for height, Case 206 representing the more usual timing, Case 184 precocious glans penis development, and Case 92 retarded glans penis development. (See pages 338–41 inclusive.)

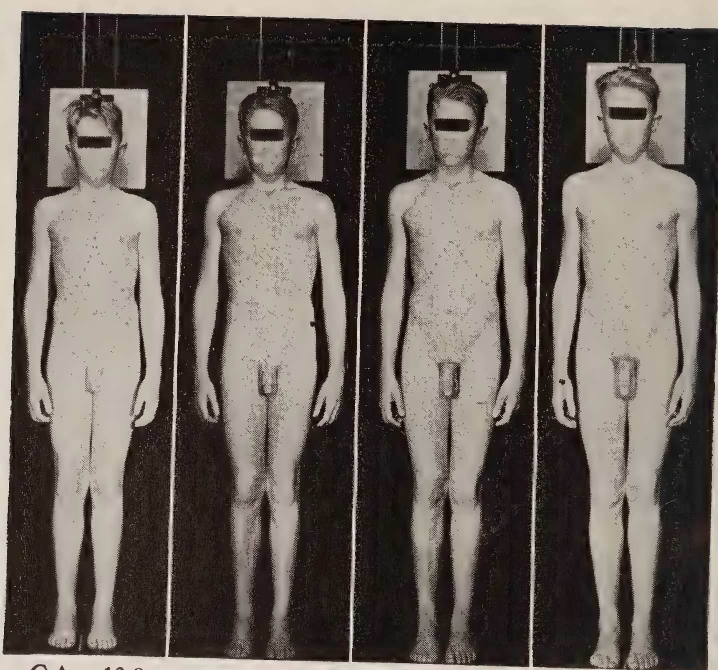
Table 90 RELATION OF END OF ACCELERATED GROWTH PERIOD FOR GLANS PENIS TO END OF PUBERAL GROWTH PERIOD FOR HEIGHT—67 BOYS

Relation of P_2 to d	*Number of Cases*	*Per Cent of 67*	*Range in Years*
End for glans penis preceding end for height	61	91.04	.20–1.25
At first examination preceding height end	21	31.34	.20– .35
At second examination preceding height end	37	55.22	.60– .80
At third examination preceding height end	3	4.48	1.15–1.25
End for glans penis at first examination following end for height	6	8.95	.25– .30
End for glans penis within:			
±.25 year from end for height	27	40.30	
−.50 year from end for height	33	49.25	
−.75 year from end for height	58	86.57	

Duration of period of accelerated growth. In general, the period of accelerated growth of glans penis began about the time of the onset of the puberal period for height and closed before the end of the puberal height period. The duration, therefore, of the accelerated growth period for glans penis was for most boys less than the period for height. There were nine cases, however, whose accelerated growth period for glans penis was between .45 year and .60 year longer than the puberal period for height.[15] In Table 91, page 341, the central tendencies of the group are compared for the two durations.

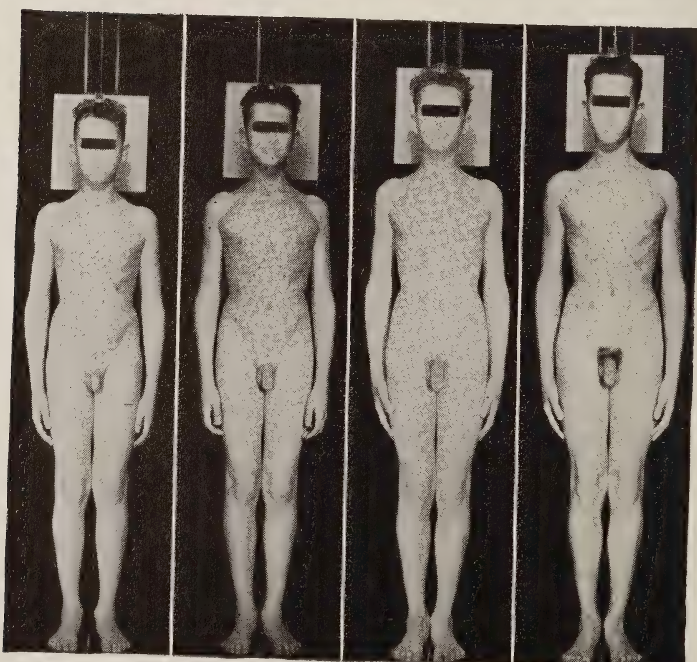
There were four boys who were among the highest ten per cent in duration of accelerated growth for both height and glans penis (Cases 74, 164, 230, and 294). But there was no boy who was among the lowest ten per cent in each distribution.

The coefficient of correlation of duration of accelerated glans penis growth and duration of puberal period for height was .305, P.E. .075, indicating a tendency for the two durations to be somewhat related. There were twelve cases where the durations of the periods for accelerated growth



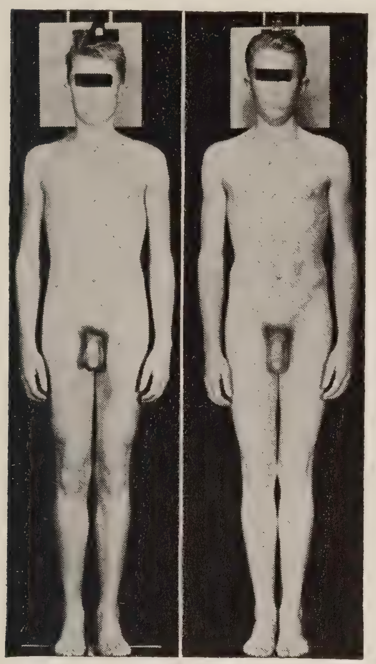
C.A. 13.8 | 14.3 | 14.8 | 15.3 P_2

FIGURE 165a.



C.A. 13.1 | 13.6 | 14.1 P_2 | 14.5

FIGURE 165b.

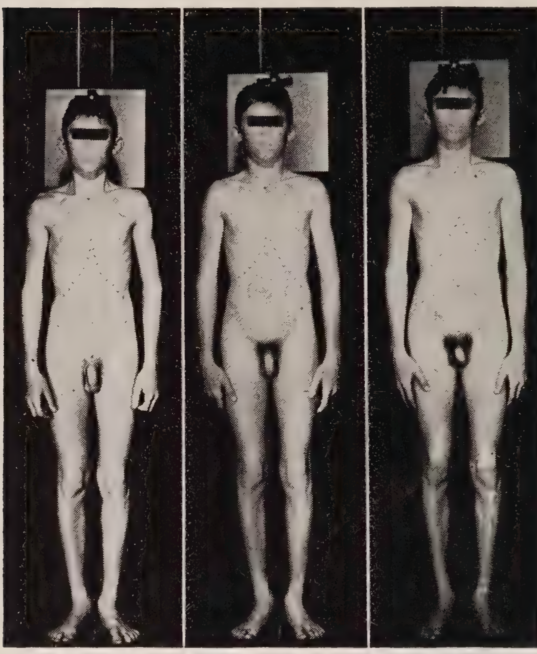


C.A. 15.8 16.4
d

FIGURE 165a. The boy in this series (Case 206) presents a usual timing relation between the end of the puberal spurt in glans penis growth and the end of the puberal growth period for height, P_2 preceding d by about nine months.

C.A. 15.0 15.5
d

FIGURE 165b. In this boy (Case 184) P_2 preceded d by 1.15 years. This is an example of early completion of acceleration in glans penis growth.



C.A. 14.3 14.8 15.3

FIGURE 165c.

of glans penis and height were the same.[16] An outstanding exception to this tendency was Case 180 who, in spite of an extremely long duration for height growth (4.05 years), had a relatively short duration for glans penis growth (2.1 years). Less extreme exceptions were Cases 92, 146, and 304 whose height growth duration was 2 years and glans penis growth duration was 2.6 years.

Section C GROWTH OF TESTES

The period of accelerated growth of the testes was determined from the photographic series by a method similar to that employed for defining the puberal growth period for the glans penis. The point at which the testes commenced to enlarge was designated T_1, and the point beyond which growth was not continuous and obvious was called T_2. The determination of these two points was less satisfactory than the determinations of P_1 and P_2 for glans penis growth because, in addition to the photographic inadequacy, the tissues judged showed greater fluctuations of size and position from photograph to photograph. Furthermore, Point T_1 frequently occurred too near the beginning of the photographic series to permit of adequate comparison, while Point T_2 was often obscured by fully developed pubic hair.

C.A. 15.9 16.3
d P_2

FIGURE 165c. In Case 92, P_2 occurred slightly after d. This illustrates late completion of acceleration in glans penis growth.

Table 91 COMPARISON OF DURATION OF ACCELERATED GROWTH PERIOD FOR GLANS PENIS AND FOR HEIGHT

	Duration Accelerated Growth Period	
	for Height Years	for Glans Penis Years
Range	1.95–4.05	1.5–3.1
Mean	2.81	2.35
Standard deviation	.53	.41
Median	2.85	2.50
Q_1	2.45	2.07
Q_3	3.16	2.64

AGE AT TIME OF ACCELERATION AND DECELERATION OF TESTES GROWTH

Data were available concerning the onset of accelerated growth of testes for 61 cases. The boys ranged in age from 9.9 years (Cases 82 and 216) to 13.3 years (Cases 78 and 218) when they reached this developmental point, a difference of 3.4 years. (See Figure 166.) This is the same range of difference that was found for P_1 except that the range for P_1 was one year later (11.0 years to 14.4 years). The mean age of acceleration of

										180					
								224	292	66					
								184	234	236					
								176	206	166		130			
							32	154	106	134		80			
						230	136	120	64	84	58	62	190		
					250	212	96	18	60	68	304	50	52		
	216			242	112	168	72	10	44	54	294	36	34	244	218
	82	110	144	164	108	100	88	116	8	40	92	24	30	220	78
Chronological age years	9.75	10.00	10.25	10.50	10.75	11.00	11.25	11.50	11.75	12.00	12.25	12.50	12.75	13.00	13.25

FIGURE 166. Distribution of 61 boys by case numbers according to age at onset of accelerated growth of testes: mean, 11.80 years; standard deviation, .784 year; median, 11.89 years; Q_1, 11.34 years; Q_3, 12.35 years.

Table 92 AGE AT ONSET OF ACCELERATED GROWTH OF TESTES—61 BOYS

Chronological Age Years	*Number of Cases*	*Per Cent of 61 Cases*
9.5– 9.9	2	3.28
10.0–10.4	2	3.28
10.5–10.9	5	8.20
11.0–11.4	9	14.75
11.5–11.9	16	26.23
12.0–12.4	13	21.31
12.5–12.9	10	16.39
13.0–13.4	4	6.56
Total	61	100.00

testes growth was 11.80 years, S.D. .784. The distribution of the 61 boys according to percentage who reached T_1 at various age levels is shown in Table 92.

There was the same range of 3.4 years in variation in the chronological age at which the 67 boys reached the end of the period of accelerated growth for testes (T_2) as there was for P_1 and T_1. The most precocious boy completed testes accelerated growth at 14.7 years (Case 250), while the latest age for completion was 18.2 years (Case 78). Case 78 was also latest in completing accelerated growth for glans penis. The mean age for T_2 was 16.38 years, S.D. .882 year. The distribution of the 66 boys according to age at end of accelerated growth of testes is shown in Figure 167. Table 93 shows the percentage who reached this stage of development at each age level.

Relation of age at onset and end of accelerated growth of testes. The correlation between age at T_1 and T_2 was .771, P.E. .033, indicating a strong tendency for these two points in development to occur in consistent relationship. This was lower than the correlation between chronological age at P_1 and P_2, which may be due to the greater difficulty in appraising testes growth.

					176										
					154										
					120						84				
					112			206			230				
					86	304	236	106	164	294	168				
					80	88	18	60	62	136	58				
				108	184	72	150	24	54	92	50				
				74	116	212	144	224	44	34	10	52	220		78
		146		242	104	100	40	134	292	234	66	244	68		190
	250	110	216	82	26	32	8	96	166	180	64	218	36		30
Chronological age years	14.50	14.75	15.00	15.25	15.50	15.75	16.00	16.25	16.50	16.75	17.00	17.25	17.50	17.75	18.00

FIGURE 167. Distribution of 66 boys by case numbers according to age at end of accelerated growth of testes: mean, 16.38 years; standard deviation, .882 year; median, 16.40 years; Q_1, 15.75 years; Q_3, 17.01 years.

Table 93 AGE AT END OF ACCELERATED GROWTH OF TESTES—66 BOYS

Chronological Age Years	*Number of Cases*	*Per Cent of 66 Cases*
14.5–14.9	3	4.55
15.0–15.4	5	7.57
15.5–15.9	16	24.24
16.0–16.4	13	19.69
16.5–16.9	12	18.18
17.0–17.4	11	16.67
17.5–17.9	3	4.55
18.0–18.4	3	4.55
Total	66	100.00

TIMING RELATIONS OF PERIOD OF ACCELERATED GROWTH OF TESTES AND PUBERAL PERIOD FOR HEIGHT

Onset of accelerated growth. The timing of the onset of accelerated growth in testes (T_1) in relation to the onset of the puberal growth period for height (b) is summarized for 61 of our 67 cases in Table 94. For 6 cases point T_1 lay outside the range of our data.

Table 94 TIMING OF ONSET OF ACCELERATED GROWTH OF TESTES (T_1) IN RELATION TO ONSET OF PUBERAL GROWTH PERIOD FOR HEIGHT (b)—61 BOYS

	Number of Cases	*Per Cent of Cases*
T_1 at fourth examination (1.75 years) before b	9	13.77
T_1 at third examination (1.25 years) before b	22	36.07
T_1 at second examination (.75 year) before b	26	42.67
T_1 at first examination (.25 year) before b	4	7.49
	61	100.00

In every case the onset of accelerated growth of testes preceded the onset of puberal growth for height. There was only a year and a half difference in the relative timing of the 61 cases, the range being from .25 year to 1.75 years before b. For 78.70 per cent of the 61 cases the onset of the puberal growth spurt for the testes occurred either 1.25 years or .75 year before the onset of puberal growth spurt for height.

The correlation between these two developmental points (T_1 and b) was .857, P.E. .022, which indicates a strong tendency for these growth phenomena to occur in sequential order.

End of accelerated growth. The timing relations between the end of the accelerated growth period for testes (T_2) and puberal period for height (d) for 66 boys are summarized in Table 95. In one case Point T_2 lay beyond the range of our data.

Table 95 TIMING OF END OF ACCELERATED GROWTH OF TESTES (T_2) IN RELATION TO END OF PUBERAL GROWTH PERIOD FOR HEIGHT (d)—66 BOYS

	Number of Cases	*Per Cent of Cases*
T_2 at first examination (.25 year) after d	13	19.69
T_2 at second examination (.75 year) after d	33	50.00
T_2 at third examination (1.25 years) after d	18	27.27
T_2 at fourth examination (1.75 years) after d	2	3.14
	66	100.00

Table 95 shows that in 50 per cent of the cases the testes growth acceleration ended at .75 year after the end of the puberal growth period for height; in 77.27 per cent it ended either .75 year or 1.25 years after d. The coefficient of correlation between T_2 and d was .889, P.E. $\pm$.017.

The similarity of timing relations between T_1 and b on the one hand, and between T_2 and d on the other, is striking. T_1 occurred at the second or third examination preceding b in 78.74 per cent of the cases while T_2 occurred at the second or third examination following d in 77.27 per cent of the cases.

Section D PATTERNS OF RELATION AMONG THE SEVERAL PHENOMENA OF PUBERAL DEVELOPMENT IN PUBIC HAIR, GLANS PENIS, AND TESTES

TIMING RELATIONS OF THE PUBERAL GROWTH PERIODS FOR GLANS PENIS AND FOR TESTES

As a further step toward describing the patterns of puberal growth for the external genitals which we found in our sample, we have combined the timing data for P_1 and T_1 and for P_2 and T_2 in relation to onset and end

of the puberal period for height so as to bring out the more usual timing relations and to show the particular cases which displayed unusual patterns. This analysis is shown in Tables 96 and 97.

Onset of accelerated growth. Accelerated growth in testes preceded accelerated growth in glans penis for all of our cases. From Table 96 it appears that the most frequently occurring pattern is T_1 at .75 year before b and P_1 .25 year after b. Of the 59 cases, 15, or 25.42 per cent, show this pattern. Of the other patterns, there are two, each of which includes 9 cases, or 15.24 per cent. In one of these T_1 is at 1.25 years before and P_1 at .25 year before b; in the second T_1 is at .75 year before and P_1 at .25 year before b.

Table 96 PATTERNS OF TIMING RELATIONS OF THE ONSET OF PUBERAL GROWTH SPURT FOR TESTES AND FOR GLANS PENIS—59 BOYS BY CASE NUMBERS

[Timing Indicated with Reference to Onset of Puberal Growth Period for Height (b)

Relation of P_1 to b	*Relation of T_1 to b* 1.75 Years Before b (b − 4)	1.25 Years Before b (b − 3)	.75 Year Before b (b − 2)	.25 Year Before b (b − 1)	Total Cases
.75 year before b (b — 2)	110 108 106 36 24	294 234 134 100			
.25 year before b (b — 1)	212 130 112 84 236 36 224	96 92 304 68 292 52 206 50 190	72 66 202 64 184 60 154 32 88		25
.25 year after b (b + 1)		242 168 164 34	44 120 218 40 116 216 30 80 176 10 78 166 8 54 144	244 62	21
.75 year after b (b + 2)		82	250 58	18	4
Total cases	12	18	26	3	59

Table 97 PATTERNS OF TIMING RELATIONS OF THE END OF THE PUBERAL GROWTH SPURT FOR TESTES AND FOR GLANS PENIS—66 BOYS BY CASE NUMBERS

[Timing Indicated with Reference to the End of the Puberal Growth Period for Height (d)]

Relation of P_2 to d / *Relation of T_2 to d*	.25 Year After d (d + 1)	.75 Year After d (d + 2)	1.25 Years After d (d + 3)	1.75 Years After d (d + 4)	Total Cases
1.25 years before d (d − 3)	294 184				2
.75 year before d (d − 2)	206 250 180 236 166 224 34 218 24 212	50 84 216 36 80 134 32 68 108 244 26 62 106 234 18 54 86 220	96 88 230 64 190 30 168 10 150		37
.25 year before d (d − 1)	110	72 154 58 120 52 116 40 100 8 82	104 78 74 292 66 164 60 136	144 44	21
.25 year after d (d + 1)		304 242 176 146 112	92		6
Total cases	13	33	18	2	66

The coefficient of correlation between the chronological ages at onset of accelerated growth of testes and of glans penis was .846, P.E. ±.021.

With respect to the length of the time interval between T_1 and P_1, 15, or 25.42 per cent, showed an interval of .5 year; 30 cases, or 50.85 per cent, an interval of 1.0 year; 13, or 22.06 per cent, an interval of 1.5 years; and 1, or 1.67 per cent, an interval of 2.0 years.

Thus, our data not only tend to corroborate the findings of Greulich [17] and others that the puberal spurt in growth of testes precedes the puberal spurt in growth of glans penis, but also show that the interval of difference is usually from .5 year to 1.5 years, with an interval of 1.0 year the most common (50.85 per cent).

Of our sample Case 82 showed the most unusual T_1–P_1 sequence pattern, with an interval of 2.0 years. In this boy the puberal spurt in testes growth was somewhat precocious in relation to the puberal spurt in height, but in the onset of puberal growth of glans penis he was among the four latest cases. All four of the cases whose acceleration in glans penis growth began as late as .75 year after b were boys who passed through an increased fat period during the early part of adolescence. Photographs showing the development of pubic hair, testes, and glans penis for Case 82 will be found in Figure 168d, pages 354 and 355.

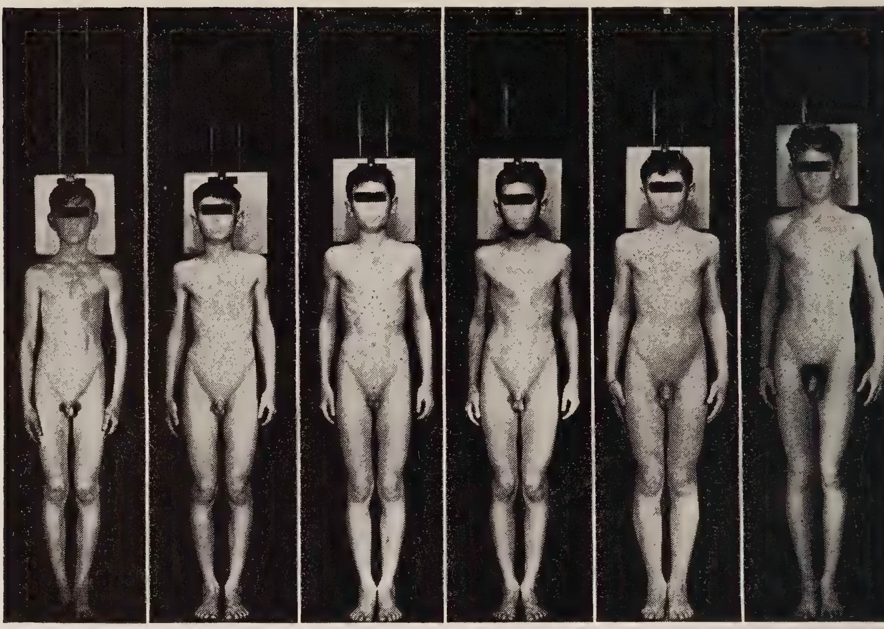
End of accelerated growth. In every case the end of the accelerated growth for testes followed the end for glans penis. In Table 97 we see that the most frequently occurring time-relation pattern for the end of the puberal spurt in testes growth, glans penis growth, and height growth includes 18 cases, or 25.75 per cent of the 66 cases analyzed. In this pattern P_2 was .75 year before d, and T_2 .75 after d. Four other patterns occurred with almost equal frequency. In one P_2 was .75 year before, but T_2 only .25 year after d; in the second P_2 was .75 year before, but T_2 1.25 years after d; in the third P_2 was only .25 year before, and T_2 .75 year after d; in the fourth P_2 was .25 year before, but T_2 was 1.25 years after d. Combined, these five patterns (the most usual pattern and the other four) include 55 cases, or 83.33 per cent of the cases.

The coefficient of correlation between chronological ages at end of accelerated testes and glans penis growth was .839, P.E. $\pm$ .024.

The interval between P_2 and T_2 varied from .5 year to 2.0 years. In 28 cases (42.42 per cent) it was 1.5 years; in 21 cases (31.82 per cent) it was 1.0 year; in 11 cases (16.67 per cent) 2.0 years; in 6 cases (9.09 per cent) .5 year. Thus, data from our sample indicated that the prolongation of the puberal growth spurt for testes after the glans penis spurt has ended is somewhat greater than the interval which separates the onset of these two phenomena. Photographs illustrating several patterns of genital development in relation to height development will be found in Figures 168a, b, c, and d, pages 348 to 355.

RELATIONS OF PUBIC HAIR DEVELOPMENT TO GLANS PENIS DEVELOPMENT AND TO TESTES DEVELOPMENT

In Section A of this chapter we discussed the timing relations of the several stages of pubic hair development to the onset, mid-point, and end of the puberal growth period for height. It remains to present the relations which we found between the development of pubic hair and testes, and pubic hair and glans penis. These relations are summarized in Table 98.



C.A. 11.0   11.6 T_1 12.0   b   12.6 P_1 13.0   13.6 P_2

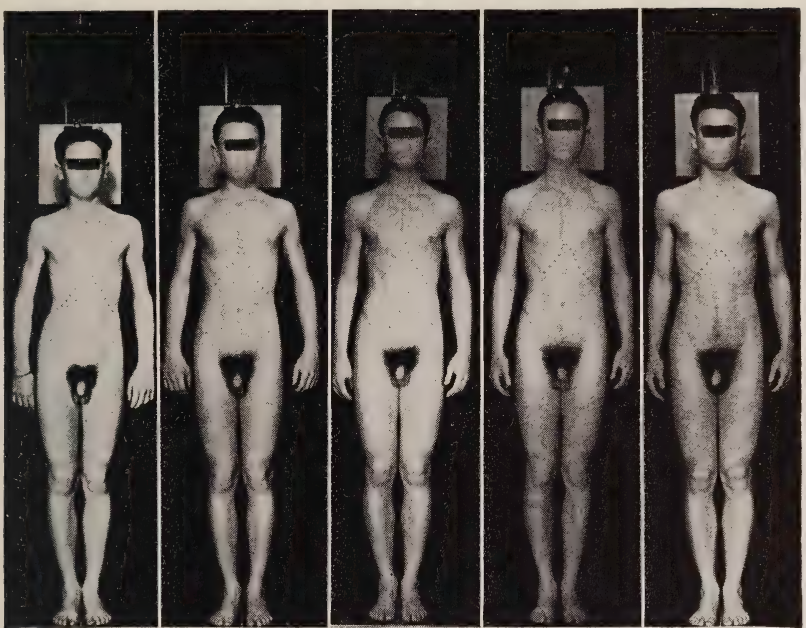
FIGURE 168a.

Table 98 PUBIC HAIR RATING AT DEVELOPMENTAL POINTS FOR TESTES, FOR GLANS PENIS, AND FOR HEIGHT—67 BOYS

Pubic Hair Rating	T_1 Number	T_1 Per Cent	P_1 Number	P_1 Per Cent	P_2 Number	P_2 Per Cent	T_2 Number	T_2 Per Cent	*b* Number	*b* Per Cent	*d* Number	*d* Per Cent
0	4	6.90										
1	40	68.96	31	46.27					35	52.24		
2	12	20.69	28	41.79					27	40.30		
3	2	3.45	8	11.94	4	5.97			5	7.46		
4					24	35.82	2	3.03			16	23.88
5					39	58.21	43	65.15			47	70.15
6							21	31.82			4	5.97
Total	58	100.00	67	100.00	67	100.00	66	100.00	67	100.00	67	100.00

At the onset of the puberal spurt in testes growth (T_1), 68.96 per cent of the cases displayed an increased development of unpigmented vellus hair in the pubic area (Rating 1), but 6.90 per cent showed no pubic hair differentiation, while 24.14 per cent showed pigmented terminals of varying lengths in addition to the increase in vellus growth (Ratings 2 and 3). Those rated either 1 or 2 constituted 89.65 per cent of the sample.

At the onset of the puberal spurt in glans penis growth (P_1) the range of pubic hair ratings had decreased (Ratings 1 to 3). The per cent of cases rated 1 or 2 (88.06 per cent) was very nearly the same as at T_1, but the proportion of 2 ratings had increased from 20.69 per cent to 41.79



C.A. 14.1 14.6 15.0 15.6 16.0

d T_2

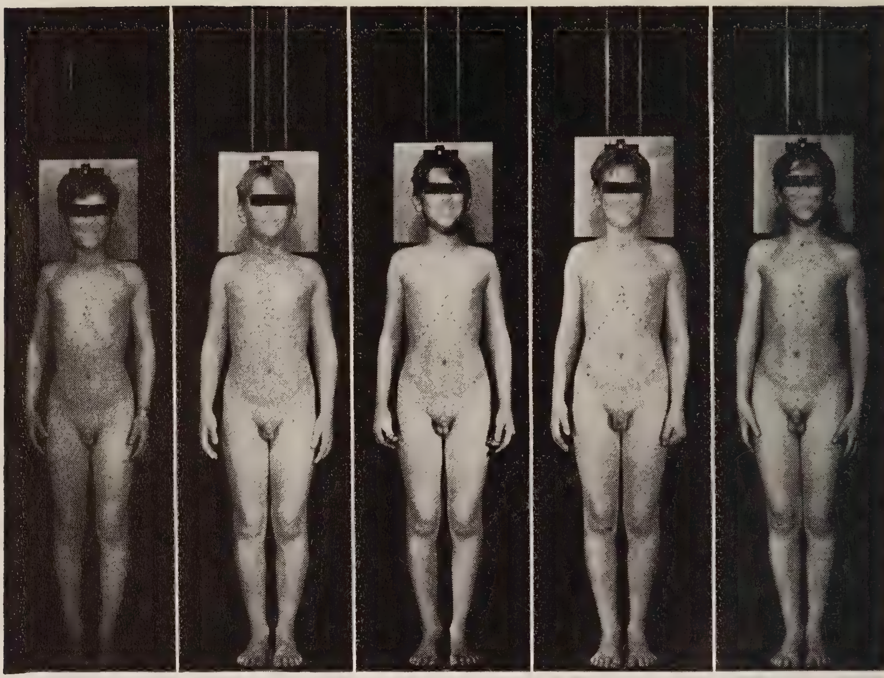
FIGURE 168a. These photographs, selected from the series for Case 80, illustrate two of the most frequently occurring patterns of timing relations among distinctive developmental points in the growth of testes, glans penis, and height. The onset of the puberal spurt in testes growth occurred at age 11.6; the onset of the puberal period for height followed .8 year later at 12.3; .3 year after this at 12.6 came the onset of the puberal spurt for glans penis. The puberal spurt for glans penis ended at 13.6; the puberal period for height ended 1.2 years later at 14.8; the puberal spurt in testes growth ended .8 year after this at 15.6 years. Approximately 25 per cent showed this timing relation pattern for T_1, P_1, and b, and approximately 25 per cent showed this timing relation pattern for T_2 and P_2 and d. Only two cases (Cases 80 and 216) showed both patterns.

per cent, and the frequency of Rating 3 had increased from 3.45 per cent to 11.94 per cent.

At the end of the puberal growth spurt for glans penis the ratings ranged from 3 to 5, with 58.21 per cent rated 5, 35.82 per cent rated 4, and 5.97 per cent rated 3. Thus, at this point every case showed pigmented terminals, but there was considerable variation in the density and area of the escutcheon growth.

At the close of the puberal growth spurt for testes all but two of the cases rated 5 or 6 in pubic hair development. Thus, on the Davenport scale 96.97 per cent had achieved maturity in this respect, Rating 6 representing merely a further extension of the area upon which terminal hair was found.

It will be noted from Table 98 that at Point T_1 approximately two thirds



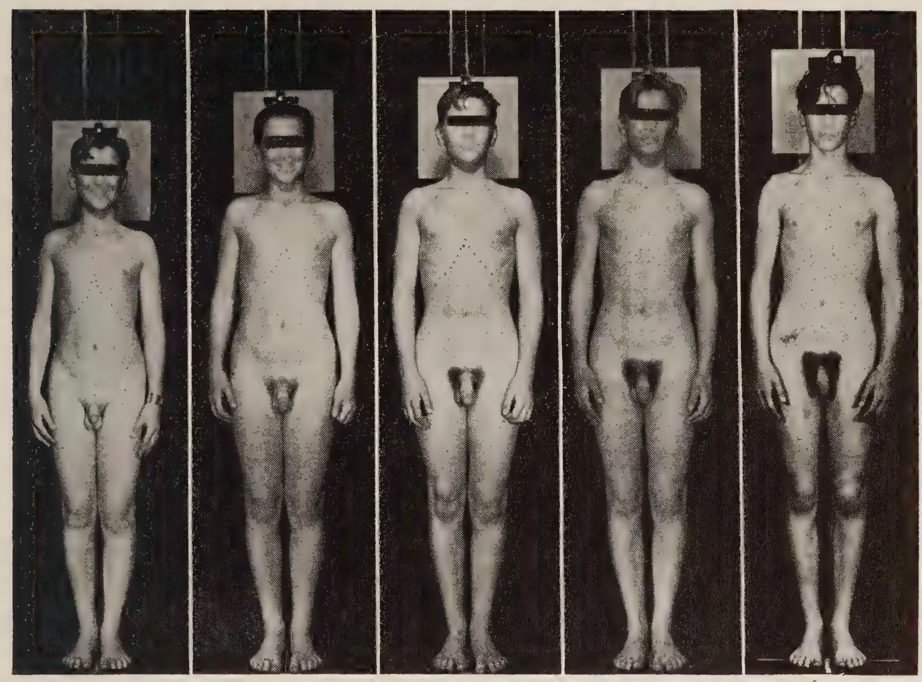
C.A. 11.9 | 12.4 T_1 | 12.9 | 13.4 P_1 | 14.0 | b

FIGURE 168b.

Table 99 PATTERNS OF PUBIC HAIR RATINGS AT DEVELOPMENTAL POINTS FOR TESTES AND GLANS PENIS

	Pubic Hair Rating at:					
Pattern	T_1	P_1	P_2	T_2	*Number*	*Per Cent*
I	1	1	4	5*	14	24.14
II	1	2	5	5	11	18.97
III	2	2	5	5	8	13.79
IV	1	1	5	5	5	8.62
V	1	1	3	5	4	6.88
VI	1	2	4	5	3	5.17
VII	0	2	5	5	2	3.45
VIII	1	3	5	5	2	3.45
IX	2	3	4	5	2	3.45
X	3	3	5	5	2	3.45
XI	0	1	4	4	1	1.72
XII	0	1	4	5	1	1.72
XIII	1	2	4	4	1	1.72
XIV	2	2	4	5	1	1.72
XV	2	3	5	5	1	1.72
					58	99.97

* In this table Ratings 6 are not shown separately but are grouped with Ratings 5.



C.A. 14.4 15.0 15.5 15.8 16.4

P_2 d T_2

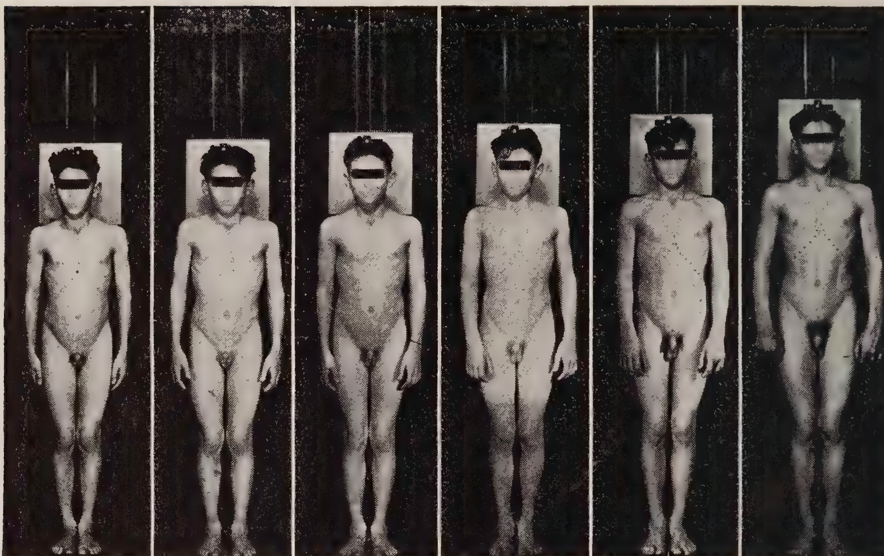
FIGURE 168b. This boy (Case 24) showed one of the less usual patterns of timing relations among T_1, P_1, and b, but his P_2, T_2, d pattern occurred in 10 of the 66 boys. In the early part of the puberal phase his height growth lagged behind his genital development; later, this tendency diminished.

of the cases rated the same in pubic hair development (Rating 1), and at Point T_2 about two thirds had the same rating (Rating 5), but at Points P_1 and P_2, which bound the period of outstanding genital growth, there was no predominant stage of pubic hair development.

In the two right hand columns of Table 98 we have included the pubic hair ratings in relation to Points b and d for height. The degree of rating correspondence is of much the same order as for P_1 and T_2, respectively. This would be expected because of the very close relation in timing of b and P_1 and the somewhat less close relation between d and T_2.

THE FREQUENCY OF IDENTICAL OR CLOSELY SIMILAR PATTERNS OF ADOLESCENT DEVELOPMENT IN PUBIC HAIR, GLANS PENIS, AND TESTES.

By listing for each individual the pubic hair rating achieved at T_1, P_1, P_2, and T_2 we found how many different patterns of growth were represented by our sample and how often each specific pattern occurred. The summary of this analysis is shown in Table 99.



C.A. 12.2   12.6   13.2   13.7   14.2   14.7

T_1 b P_1

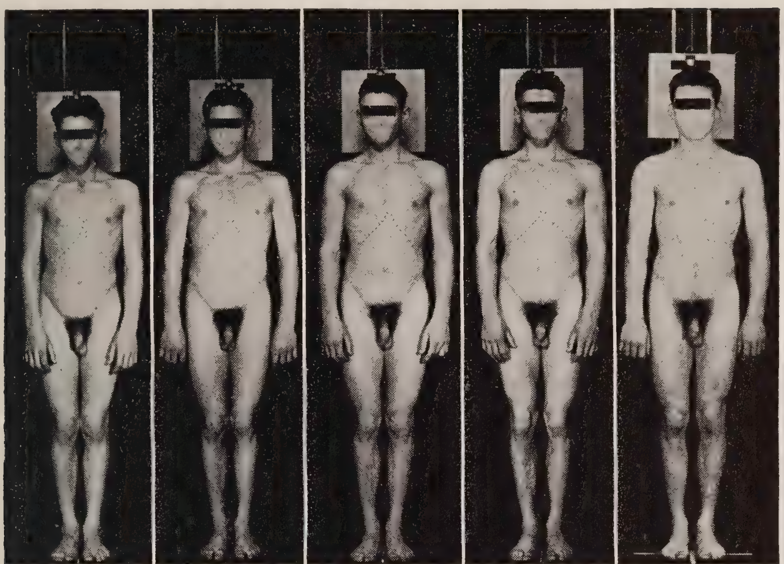
FIGURE 168c.

Table 99 shows the general correspondence of stages of pubic hair development to stages in the growth of glans penis and testes but emphasizes the very considerable variation in sequential correspondence. The 58 cases analyzed yielded fifteen patterns. The two most frequently occurring patterns included 43.11 per cent of the cases; the four most frequent represented 65.52 per cent of the sample. On the other hand, four patterns included two cases each, and each of five cases displayed its own distinctive pattern.

SUMMARY

In this chapter we have attempted to bring together several sorts of data bearing upon the process of sexual maturation in boys during adolescence. We have studied stages of development for pubic hair, testes, and glans penis as recorded for our sample, with special attention to the timing relations among them and also to the relations with stages of growth in height.

For pubic hair the data were rating scale values determined at each semiannual examination. For glans penis and testes two developmental points for each were determined by inspection of the photographic series. These points were the onset (T_1) and end (T_2) of the puberal growth spurt for testes, and the onset (P_1) and end (P_2) of the puberal growth spurt for glans penis.



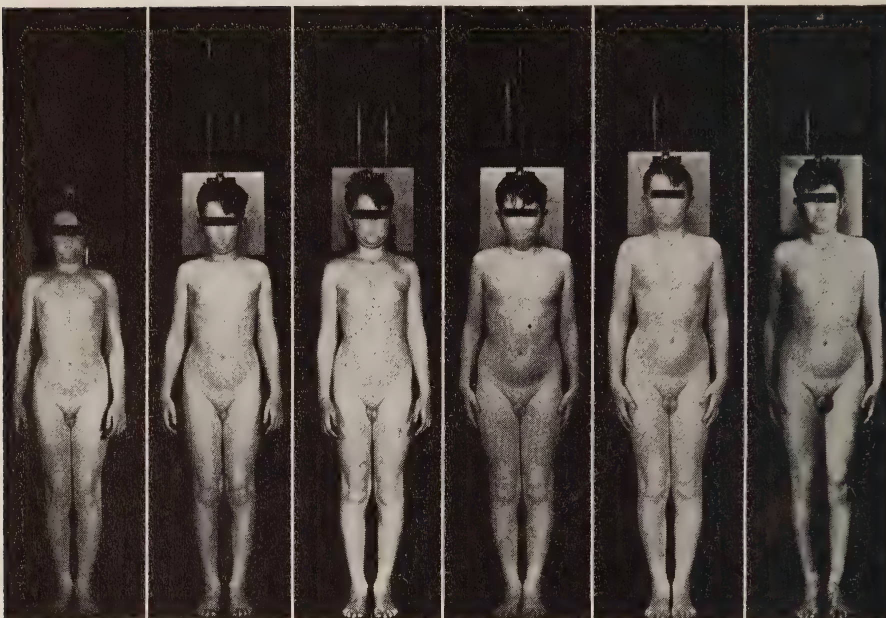
C.A. 15.2 P_2 | 15.7 | 16.3 d | 16.7 T_2 | 17.3

FIGURE 168c. This boy (Case 62) showed the corresponding puberal onset points for testes, glans penis, and height all occurring within less than a year. His puberal ending pattern, however, was less concentrated, with a span of 1.5 years between P_2 and T_2, with d occurring at the middle of the span.

The pubic hair ratings (0 to 6) were analyzed in relation to Points b — 3, b, c, d, and d + 3 on the height growth profiles. For our sample the ratings at Point b — 3 in the prepuberal period ranged from 0 to 3; at b from 1 to 3; at c from 1 to 5; at d from 4 to 6; at d + 3 from 5 to 6. Only during the prepuberal and postpuberal periods did a specific stage of pubic hair development show approximate correspondence with a specific stage of height development.

During the puberal period there was wide variation in the rate at which pubic hair developed. The coefficient of correlation between rating at onset and end being .181, P.E. ±.079. The gain on the rating scale ranged from 1.5 to 5 points and averaged slightly over 3 points. There was a definite tendency for the rate of gain in pubic hair development to be greater during the first half of the puberal period than during the last half, but here again there was a wide range of individual variation.

Analysis of the time at which each boy *first* achieved each of the successive stages of pubic hair development indicated that throughout adolescence steady rate of change was the exception. A few boys passed from one specific stage to the next in less than six months, while some of their fellows required as much as three years to accomplish a similar transition.



C.A. 9.9 10.6 10.9 11.5 12.0 12.5
T_1 b P_1

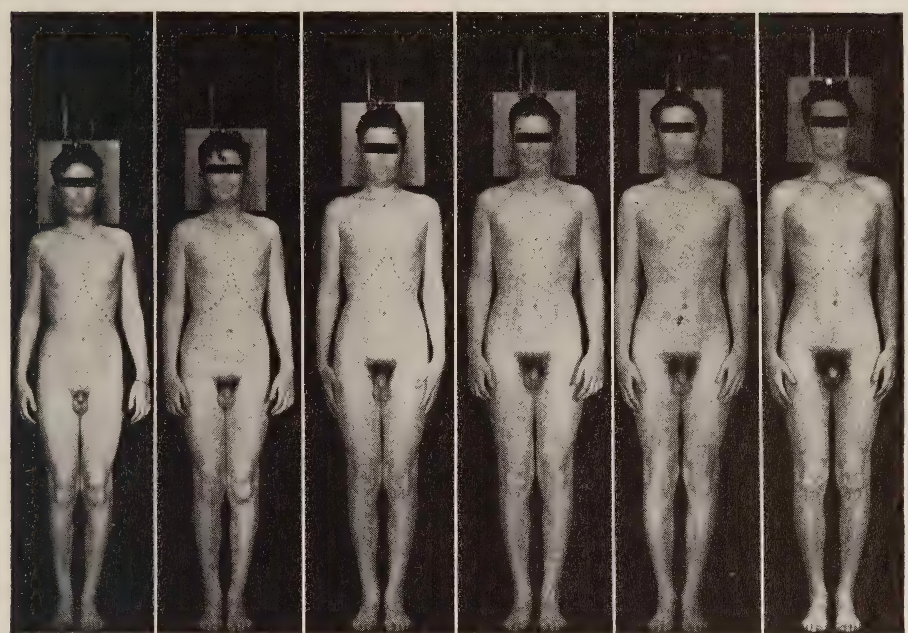
FIGURE 168d.

All the analyses of pubic hair development as it occurred in this sample of boys emphasized the limitations of such ratings for determining general somatic progress toward maturity.

There was a marked tendency toward synchrony between puberal acceleration in glans penis growth and height growth. In about four fifths (79.10 per cent) of the cases the onset of the puberal spurt in glans penis growth occurred within four months (.35 year) of the onset of the puberal period for height. The mean of the differences in chronological age was .07 year.

There was an equally close relation in ending time for the puberal phase of these two aspects of development, although the endings were not synchronous. Of 67 cases, 55.22 per cent ended the puberal spurt in glans penis growth at nine months before the end of the puberal period for height; in over nine tenths of them the end of the glans penis growth spurt occurred from .25 year to 1.25 years before the end of the puberal period for height.

Although the determination of the onset and end of puberal spurt in growth of the testes from the comparison of photographic records was less exact than for the glans penis, there was evidence of close correlation between these points and the limits of the puberal period for height. Onset of puberal growth for testes preceded onset of the puberal period for height by from .25 year to 1.75 years; in 78.70 per cent of cases it occurred



C.A. 13.0 13.6 14.2 14.7 15.3 15.8

P_2 d T_2

FIGURE 168d. Case 82 was an early developer whose testes probably started on the puberal spurt at 9.9 years, but his glans penis did not commence puberal growth acceleration until two years later. This retardation was probably connected with his marked early adolescent fat period. The P_2, d, T_2 timing pattern at the end of the puberal phase was not unusual.

from .75 year to 1.25 years before b; the correlation between T_1 and b was .857, P.E. $\pm$.022.

The puberal spurt in testes growth ended from .25 year to 1.75 years after the end of the puberal period for height; in 77.27 per cent of cases the range was from .75 year to 1.25 years after d; the correlation between T_2 and d was .889, P.E. $\pm$.017.

Thus, from data based upon two developmental points for each, glans penis growth and testes growth showed a timing pattern which closely paralleled the pattern for height growth. The close relation between height development and genital development, both at the beginning and the end of the puberal period, would seem to indicate a significant integration among these several patterns.

A separate analysis confirmed the deduction that only early in the prepuberal and late in the postpuberal periods was there a definite tendency for specific pubic hair ratings to correspond to specific stages in the development of the external genitalia.

FOOTNOTES FOR CHAPTER XIV

[1] Crampton, C. Ward: "Physiological Age—A Fundamental Principle." *Child Development,* **15**:1–52, 1944. Reprint of earlier papers.

[2] Danforth, C. H.: *Hair, with Especial Reference to Hypertrichosis.* American Medical Association, Chicago, 1925.

Greulich, W. W., *et al.:* "A Handbook for the Study of Adolescent Children." Monograph, Society for Research in Child Development. **3**:35–38, 1938.

[3] See discussion, Chapter III, page 34.

[4] For a detailed description of the rating scale, see page 34.

[5] See Appendix U for complete data on pubic hair ratings for 67 boys.

[6] Rate was computed by dividing puberal gain in pubic hair rating by duration of the puberal period.

[7] One boy, whose records are incomplete, received Rating 2 as early as 3.35 years before puberal onset (Case 236).

[8] Data for eleven of these boys are not included in Table 85 because the first record of Rating 2 came at the initial examination; one case had Rating 3 at the initial examination.

[9] This range may have been even wider if we had had earlier records on Case 136 whose initial examination at 2.45 years before b showed a pubic hair rating of 2.

[10] This is due to the fact that 46 cases had Rating 1 at the first examination in the study.

[11] See pages 230, 231, and 232.

[12] Greulich, W. W., *et al.*: "Somatic and Endocrine Studies of Puberal and Adolescent Boys." Monograph, Society for Research in Child Development, **7**:3, 1942.

[13] For a detailed description of the method of rating and data for this section, see Appendix V.

[14] Since the possibility of making such determinations from the photographic series emerged only as the photographs accumulated, the lighting conditions had not been planned to obtain optimum photographic definition for the genital area. Consequently, the enlarged reproductions shown in Figure 161 are not as convincing as we would wish for a technique which we hope will be used and tested by other investigators.

[15] For six additional cases the duration of the accelerated growth period for glans penis exceeded duration of the puberal growth period for height by .05 year.

[16] Cases 66 and 292 (2 years); Cases 36, 50, 154, and 176 (2.5 years); Cases 60, 108, and 242 (2.6 years); Case 72 (3.0 years); Cases 136 and 234 (3.1 years).

[17] Volume VII, No. 3 (Serial No. 33) Monograph, Society for Research in Child Development.

Chapter XV INCREASE IN ADIPOSE TISSUE DURING EARLY ADOLESCENCE

FROM time to time parents, teachers, and physicians have noticed and remarked that some boys seem to go through a period of plumpness as childhood merges with early adolescence, but, as far as we are aware, there have been few, if any, published descriptions of the frequency, variations, and significance of this phenomenon.[1] Since our serial measurements of subcutaneous tissue thickness and our serial photographic records yield unusual data concerning this, and since at least ten per cent of our boys were significantly disturbed as they experienced it, we feel that it calls for special description and discussion.

In Chapter IX we have shown by statistical analysis of the data for our sample that there was a specific sequential pattern of change in the thickness of subcutaneous tissue during adolescence. In this chapter we focus attention upon a particular part of that sequential pattern: the period of transition from prepuberal to puberal development as defined by the phenomena of height growth.

In studying the photographic records we were surprised to find that this transitory increase in fatness was by no means an occasionally occurring phenomenon, but that it was obvious in about one half of our sample. It occurred not only in boys who were consistently above average in amount of subcutaneous tissue throughout the seven year period but also in boys of average adiposity and occasionally in boys who were below average in this respect both before and after the fat period.

This fat period varied widely both in intensity and in duration, but it bore a strikingly consistent time relation to the onset of the puberal growth period for height (b) and also to the onset of the puberal spurt in glans penis growth (P_1).

CLASSIFICATION OF BOYS

From the recorded caliper measurements of the subcutaneous tissue on upper arm, abdomen, and hip, and from comparison of the photographs taken semiannually we divided our cases into four groups, as follows:

A. No increase, or increase of less than 5 millimeters in the sum of the measurements of subcutaneous tissue, at or close to the puberal onset for height. (Illustrated in Figure 169a, page 360.)

B. Increase of 5 millimeters or more in combined measurements. Increase does not show unmistakably in the photographs. (Illustrated in Figure 169b, page 361.)

C. Increase of 5 millimeters or more in measurements with corresponding definite but not striking change in appearance in photographs. (Illustrated in Figure 169c, page 362.)

D. Increase of 5 millimeters or more in measurements with corresponding striking change in appearance in the photographs. (Illustrated in Figure 169d, page 363.)

In comparing photographs with reference to the amount of subcutaneous tissue, we found that when the increase was slight or moderate it was usually most evident about the face and neck, in the pubic region, and over the buttocks. In cases in which the amount of adipose tissue changed markedly, the increase was obvious, also, over the abdomen, hips, and limbs, and in the breast areas. In such cases the circumference measurements of arm, thigh, and leg corroborated the appearance and the subcutaneous tissue measurements. In a few cases even the changes in body weight clearly reflected the phenomenon of transitory fatness.

The distribution of our 67 boys (and of a supplemental sample of 13 cases) among the four groups A, B, C, and D is summarized in Table 100. In Figures 169a, b, c, and d we present photographic series for four boys who represent the four groups.

Table 100 EARLY ADOLESCENT FAT PERIOD

Distribution of 80 Cases by Groups According to Degree of Fatness

Group	*Number*	*Per Cent*
A—fat period absent or doubtful	28	35.00
B—fat period definite but not obvious	15	18.75
C—fat period obvious but not striking	16	20.00
D—fat period strikingly obvious	21	26.25
	80	100.00

The frequency distribution summarized in Table 100 was based upon judgment which combined both measurements and photographic appearance. We have included in Groups B, C, and D only those cases in which the evidence for a transitory fat period was definite and consistent. On the basis of the analysis of this sample we believe that in any unselected group

of adolescent boys about two thirds will exhibit this interesting phenomenon in some degree, while at least a quarter of them will show it with striking clearness. For ease of reference we have designated this phenomenon *the early adolescent fat period.*

THE TIMING RELATIONS OF THE EARLY ADOLESCENT FAT PERIOD

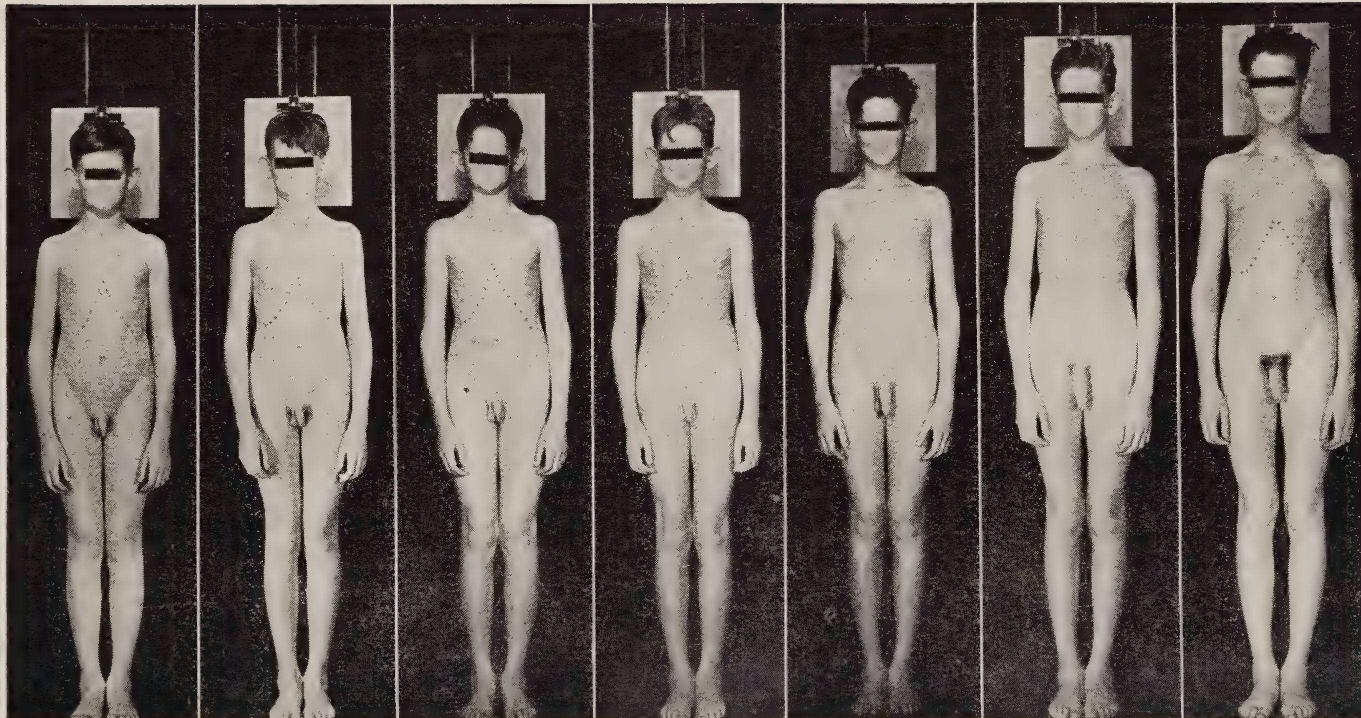
Timing of the peak. As with so many other phenomena of development there was some difficulty in determining for every case the exact time at which the cycle of fat increase-decrease began and ended, but there was relatively little difficulty in judging when it peaked. From our analysis of 44 cases [2] we concluded that this early adolescent fat period peaked within $\pm.25$ year of the onset of the puberal period for height (b) in 27 boys (61.36 per cent), that in 6 boys (13.63 per cent) it peaked from .75 year to 1.25 years before b, and that in 11 boys (25.0 per cent) it peaked .75 year to 1.25 years after b. (See Table 101.)

The timing relation with the onset of the puberal spurt in glans penis growth was equally close, with the fat period peaking at P_1 in 18 (40.91 per cent) of the 44 cases, from .5 year to 1.0 year preceding P_1 in 8 cases (18.18 per cent) and from .5 year to 1.0 year following P_1 in 18 cases (40.92 per cent). (See Table 101.)

Table 101 RELATION OF THE TIMING OF THE EARLY ADOLESCENT FAT PERIOD TO PUBERAL ONSET FOR HEIGHT GROWTH AND FOR GLANS PENIS ACCELERATED GROWTH—44 BOYS

Peak of Fat Period	*In Relation to b*		*In Relation to P_1*	
	Number	Per Cent	Number	Per Cent
1.25–.75 years before	6	13.63		
0.25 year before or after	27	61.36		
0.75–1.25 years after	11	25.00		
1.00 year before			4	9.09
0.50 year before			4	9.09
Synchronous			18	40.91
0.50 year after			13	29.56
1.00 year after			5	11.36

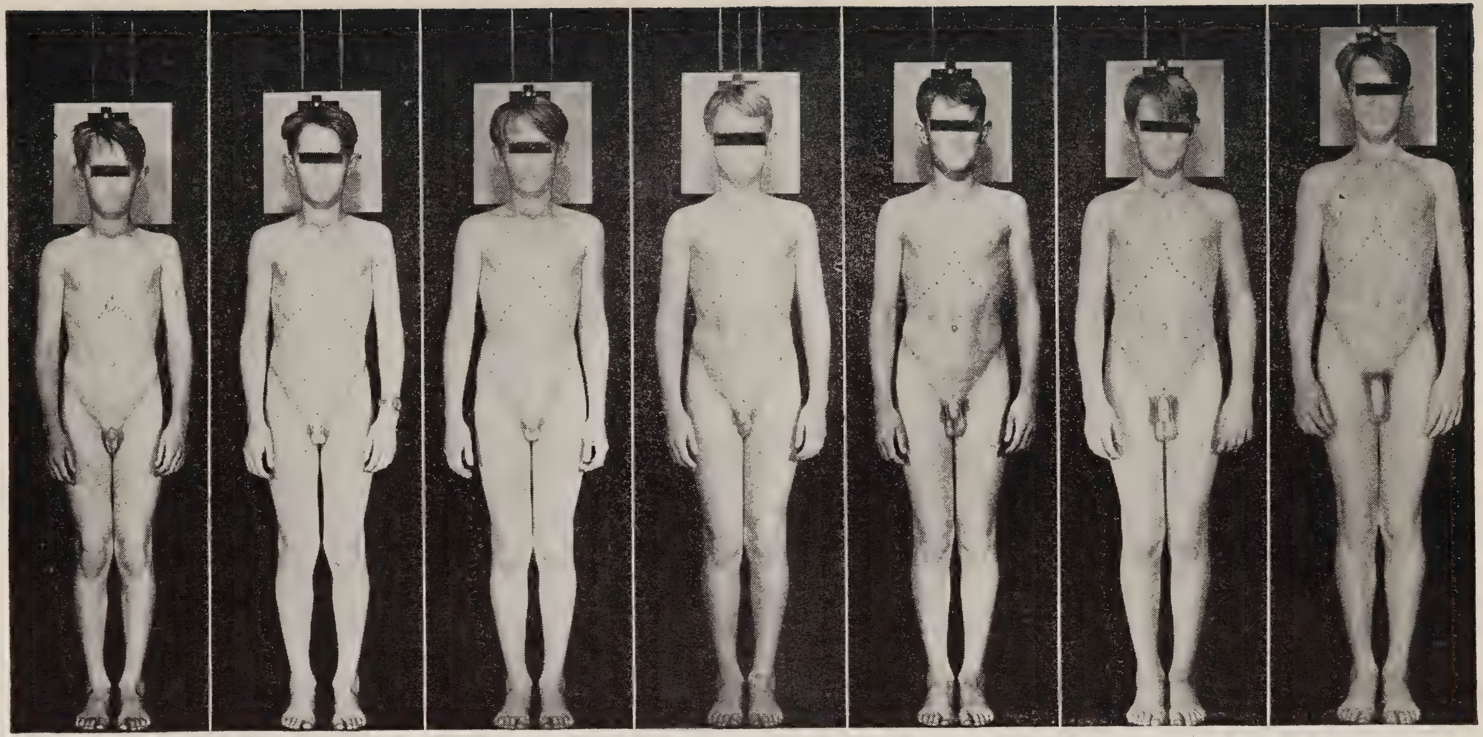
Table 102 shows the relation of the peak of this early fat period with both the onset of the puberal period for height and for glans penis accelerated growth. In about half of the cases this fat period peaked around the onset of height and was either synchronous with accelerated glans penis growth or followed it. In 18.18 per cent of the cases it occurred following both the onset of puberal height growth and the onset of accelerated glans penis growth.



C.A. 12.9 13.4 13.9 14.4 14.9 15.4 15.8

b

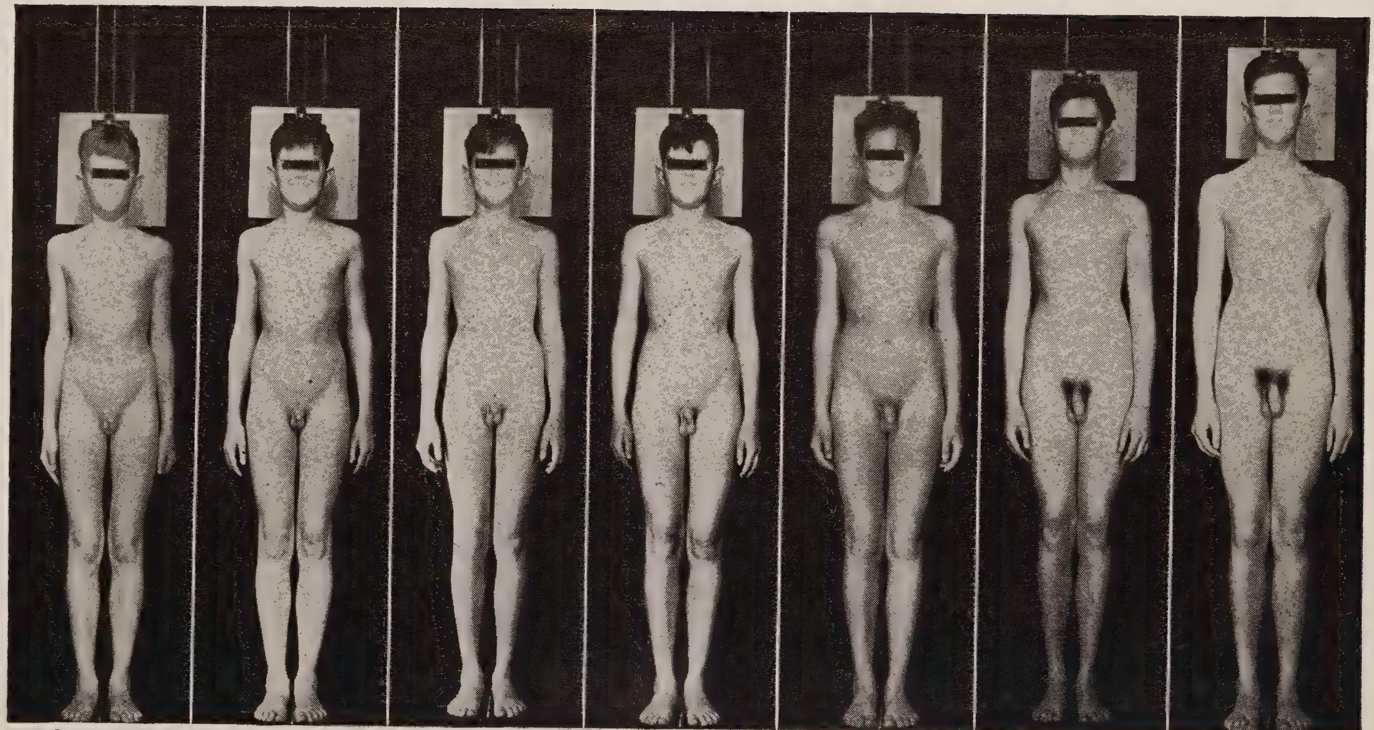
FIGURE 169a. The first series is of a boy (Case 52) who did not show any increase in subcutaneous tissue measurements at or near the transition (b) from prepuberal to puberal growth in height. He represents Group A which constituted 35 per cent of the sample.



C.A. 11.7 12.4 12.7 13.2 13.6 14.1 14.6

b

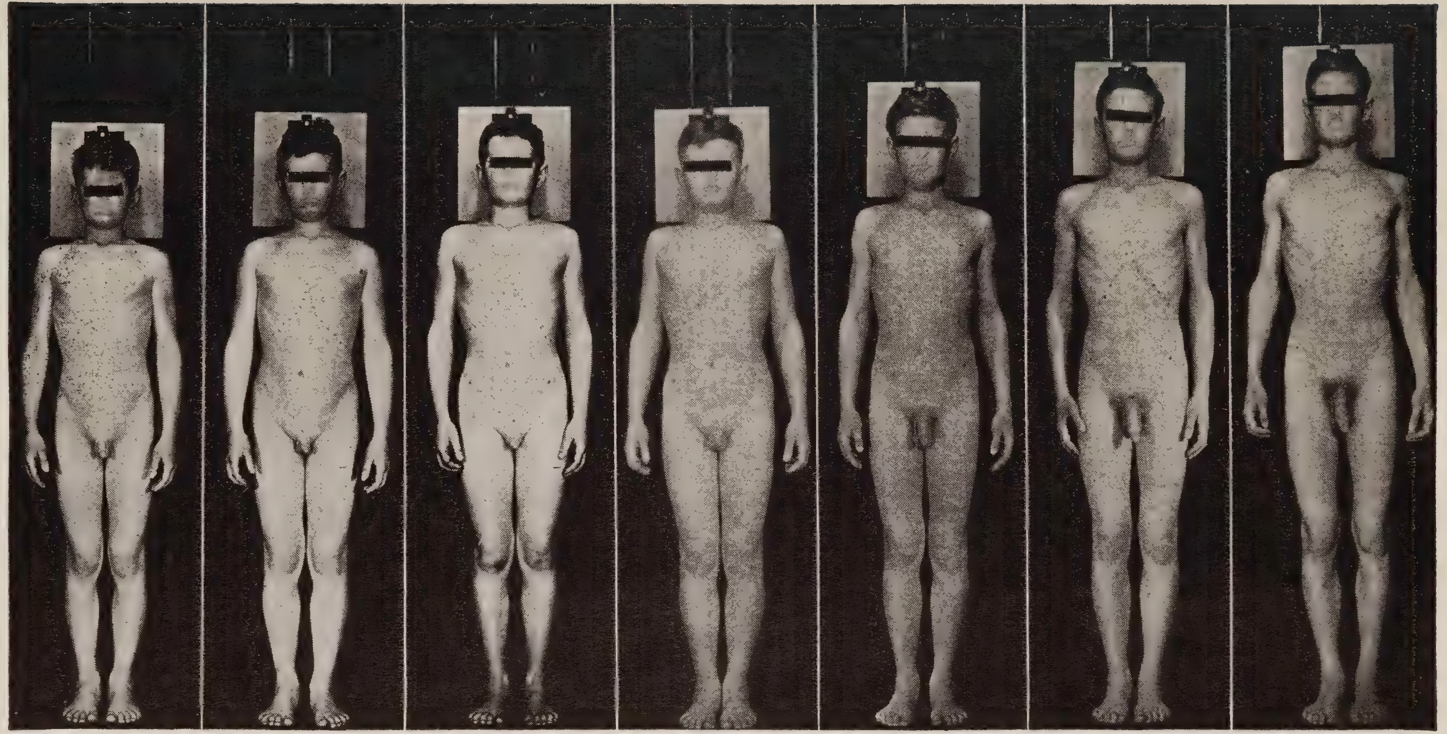
FIGURE 169b. The second series shows a boy (Case 10) who did have a fat period near the puberal onset as shown by measurements, although the increase was not obvious from the photographs. He represents Group B (18.75 per cent).



C.A. 12.7 13.2 13.7 14.2 14.7 15.1 15.7

b

FIGURE 169c. The third series shows a boy (Case 84) whose appearance, as well as measurements, demonstrate the obvious fat period near the puberal onset for height. He represents Group C (20.0 per cent).



C.A. 11.1 11.8 12.1 12.6 13.1 13.6 14.1

b

FIGURE 169d. The fourth series shows a boy (Case 44) in whom the fat period was an easily recognized and rather striking phenomenon. He represents Group D (26.25 per cent).

Table 102 TIMING RELATIONS OF THE PEAK OF THE EARLY ADOLESCENT FAT PERIOD—44 BOYS

Relation to Onset Puberal Growth of Glans Penis (P_1)	*Relation to Onset Puberal Period for Height (b)*							
	Before		Synchronous		After		Total Cases	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Before	4	9.09	4	9.09	0	0	8	18.18
Synchronous	2	4.54	13	29.54	3	6.82	18	40.91
After	0	0	10	22.72	8	18.18	18	40.91
Total Cases	6	13.63	27	61.36	11	25.00	44	100.00

Timing of onset and end of the fat period. There is some difficulty in determining the exact age when the fat period began and ended for every individual. Sometimes there are minor fluctuations which may or may not belong within the period, and occasionally we find a case in which there is some question whether the fat period includes one or two major peaks. It is possible, however, to indicate with a reasonable degree of certainty the developmental periods (for height) during which the fat period began and ended. Our findings for the 44 boys who showed an early adolescent fat period are summarized in Table 103.

Table 103 TIMING OF EARLY ADOLESCENT FAT PERIOD—44 BOYS

Timing of Onset of Fat Period	*Number of Cases*	*Per Cent of Cases*
In prepuberal period	42	95.45
At puberal onset of height	2	4.55
Timing of End of Fat Period		
At puberal onset of height	4	9.09
First half puberal period	29	65.91
Mid-point puberal period	9	20.45
Last half puberal period	1	2.27
Postpuberal period	1	2.27

From this table it can be seen that all of the cases began the fat period either before the onset (b) for puberal height growth (95.45 per cent) or at that point (4.55 per cent). For about two thirds of the cases (65.91 per cent) the fat period ended during the first half of the puberal period.

A few cases (9.09 per cent) ended at the height onset (b), one case ended in the latter half of the puberal period, and in one case the fat phenomenon was prolonged into the postpuberal period.

Duration of the fat period. In 34 of the 44 cases it was possible to determine the duration of the fat period.[3] The results are shown in Table 104. The range of duration was from one to three and a half years. Of the 34 cases of which the duration was known, slightly less than half (47.26 per cent) had a duration of two years. More than three fourths of the cases (79.12 per cent) fell between 1.5 years and 2.5 years.

Table 104 DURATION OF FAT PERIOD—44 BOYS

Duration in years	1	1.5	2.0	2.5	3.0	3.5	Unknown
Number of cases	1	4	16	6	3	4	10
Per cent of cases	2.27	9.09	36.36	13.63	6.82	9.09	22.73

OTHER GROWTH CHARACTERISTICS ASSOCIATED WITH THE FAT PERIOD

Of the 37 boys who showed an *obvious* fat period (see Groups C and D, Table 100), 33 were among the sample of 67 boys whom we studied intensively. It was possible, therefore, to analyze their relation to the group in other growth characteristics. We were interested in finding out whether these 33 boys who went through a fat period in early adolescence manifested other growth phenomena which would distinguish them from the total sample of 67 cases.

In Table 105 we show the quartile distribution of these 33 cases in relation to timing of the puberal growth period and according to measurements of height, biacromial/bi-iliac ratio, subcutaneous tissue index, thigh circumference, weight, and strength index. In Table 106 is shown the percentage of these 33 cases which fell below or above the median of the total sample.

Probably the most significant finding is that in each of the items the 33 boys were distributed among the four quartiles. The fat period occurred in boys whose puberal period for height occurred early (Case 82), at the average chronological age (Case 64), and late (Case 50). There was a stronger tendency for these boys to be either early (30.3 per cent) or late (33.33 per cent) developers than for the group as a whole.

There was a slight tendency for these boys to have a longer-than-average duration of the puberal period. But, again, there were boys with a very short duration (Case 66), with an average duration (Case 250), and an extremely long duration (Case 74).

Table 105 DISTRIBUTION OF 33 FAT BOYS AS TO OTHER GROWTH PHENOMENA

(Number of Cases in Quartile Distribution of Total Group of 67 Boys)

	Number of Cases in Each Quartile				
	First	Second	Third	Fourth	Total
Chronological age at onset puberal period	10	4	8	11	33
Chronological age at end puberal period	9	7	8	9	33
Duration puberal period	7	8	12	6	33
Height					
Prepuberal	5	9	9	10	33
Postpuberal	4	9	9	11	33
Biacromial/bi-iliac ratio					
Prepuberal	10	8	12	3	33
Postpuberal	10	11	9	3	33
Subcutaneous tissue rating					
Prepuberal	3	10	6	14	33
Postpuberal	3	7	11	12	33
Thigh circumference					
Prepuberal	5	3	11	14	33
Postpuberal	4	7	11	11	33
Weight					
Prepuberal	2	10	9	12	33
Postpuberal	4	7	11	11	33
Strength					
Prepuberal	7	5	12	9	33
Postpuberal	9	9	5	10	33

Table 106 DISTRIBUTION OF 33 FAT BOYS AS TO OTHER GROWTH PHENOMENA

(Percentage Above or Below the Median of Total Group of 67 Boys)

	Percentage Above the Median of the Total Group		*Percentage Below the Median of the Total Group*	
Chronological age at onset puberal period	57.57			
Duration puberal period	54.54			
Measurement	*Prepuberal*	*Postpuberal*	*Prepuberal*	*Postpuberal*
Height	57.57	60.61		
Biacromial/bi-iliac			54.54	63.63
Subcutaneous tissue	60.61	69.70		
Thigh circumference	75.76	66.67		
Weight	63.63	66.67		
Strength	63.63			54.54

During the prepuberal period slightly more than half (57.57 per cent) were above the median in height, and by the postpuberal period the percentage above the median in height had increased to 60.61 per cent.[4]

Among these 33 boys there were only three who had extremely broad shoulders and narrow hips in the postpuberal period (Cases 18, 144, 234). Most of the cases (63.63 per cent) were below the median in biacromial/bi-iliac ratio at that time.

Early in the prepuberal period (b — 3) a majority of these boys (63.63 per cent) were above the median in muscular strength, but late in the postpuberal period (d + 3) this relation had been reversed. However, there were boys who continuously showed great muscular strength (see Case 218 in Figure 155c) as well as some who continuously showed relatively little. (See Case 36 in Figure 57b, page 103.)

There was a marked tendency for these fat boys to have a large thigh circumference, to weigh above the median of the group, and to have a subcutaneous tissue rating above the median of the group at both the beginning and end of their adolescent growth period, as well as during the fat period itself.

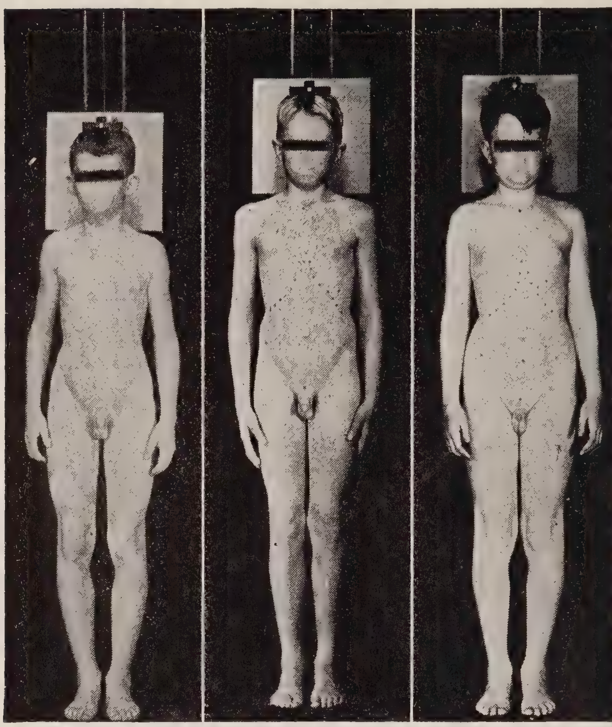
MALE-INAPPROPRIATE CHARACTERISTICS

In our culture being noticeably fat during adolescence is considered undesirable for either boys or girls. In boys such fatness frequently carries with it the implication of sex inappropriateness. Having found that the phenomenon of obvious early adolescent fat increase occurred in 50 per cent of our sample, we were interested in finding out whether or not it was associated with other somatic characteristics which are thought to be male-inappropriate.

Of our sample of 66 boys,[5] 33 fell in Groups A and B and 33 fell in Groups C and D as regards early adolescent fat increase. (See classification categories, page 358.) Thus, one half of our sample showed no tendency at all or only a very slight tendency to manifest this phenomenon, while the other half showed an unmistakable tendency to exhibit it. This facilitated comparison.

The following items were used in rating male inappropriateness of somatic development:

1. Simulation of female breast development
2. Simulation of female girdle pattern of fat distribution
3. Simulation of female thigh-leg configuration
4. Retardation of pubic hair development and simulation of female pattern of body hair distribution



Case 40 **Case 206** **Case 82**

FIGURE 170. Photographs of three boys who at the same stage in height development (b) represented varying degrees of simulated breast development. Case 40 at the left showed no such tendency; Case 206 in the middle showed increased fat in the breast areas but no noticeable female breast contour; Case 82 at the right showed fat increase, nipple invagination, and a definite simulation of an early stage in female breast development. Boys with an early adolescent fat period in comparison with the whole group tended to have more breast development both during the fat period and later.

5. Small diameter of glans penis
6. Low biacromial/bi-iliac ratio
7. Low achievement in tests of muscular strength

The verbal description of sex-appropriate and sex-inappropriate somatic characteristics becomes more meaningful and more useful when supplemented with visual illustrations. Such illustrations are shown in Figures 170 through 176.

Simulation of female breast development. Among the boys of our sample there were several who were disturbed because of soft tissue development under and around the nipples which seemed to resemble the incipient breast development of females. At the other end of the scale were boys, at the same stage of development, whose chest contours were completely molded

by the underlying bones and muscles. Between these extremes were many boys with varying amounts of soft tissue padding in these areas.

The "breasts" of the 66 boys were studied at two developmental points —the onset of the puberal period and during the postpuberal period. At the puberal onset the fat boys were in the midst of their early adolescent fat period; at the postpuberal point they were several years beyond it. The boys were divided into three groups representing the lowest quartile, the middle fifty per cent, and the upper quartile in breast-like development.[6] These ratings were based on comparative study of the serial photographs and on clinical notes made at the time of examination.[7] Consideration was given to (1) the amount and distribution of soft tissue around the nipple, (2) the size and prominence of the nipples, and (3) the size and pigmentation pattern of the areolae. The quartile distribution of the 33 fat boys and the other 33 boys according to the amount of breast-like development as determined by these clinical criteria is given in Table 107. In Figure 170 we show three boys who represent the differences of the three distribution groups.

None of the fat boys was in the lowest quartile (least breast development) at either the onset of the puberal period or during the postpuberal

Table 107 QUARTILE DISTRIBUTION OF BOYS IN ITEMS INDICATING DEGREE OF MASCULINITY

(1 = Highest Degree of Masculinity)

		Onset Puberal Period (b)				*Postpuberal Period (d + 3)*			
		Fat Boys—33		Others—33		Fat Boys—33		Others—33	
Item	*Quartile Rating*	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Breast-like development	1	0	0	16	48.48	0	0	16	48.48
	2–3	18	54.54	16	48.48	21	63.63	13	39.39
	4	15	45.45	1	3.33	12	36.36	4	12.12
Girdle accentuation	1	0	0	16	48.48	0	0	16	48.48
	2–3	17	51.50	17	51.50	19	57.57	15	45.45
	4	16	48.48	0	0	14	42.42	2	6.06
Leg and thigh alignment	1	3	9.09	13	39.39	14	12.12	12	36.36
	2–3	15	45.45	19	57.57	15	45.45	19	57.57
	4	15	45.45	1	3.03	14	42.42	2	6.06
Body hair	1	9	27.27	7	21.21	7	21.21	9	27.27
	2–3	14	42.42	20	60.61	17	51.50	17	51.50
	4	10	30.30	6	18.18	9	27.27	7	21.21
Glans penis circumference	1	8	24.24	8	24.24	9	27.27	8	24.24
	2–3	16	48.48	18	54.54	16	48.48	16	48.48
	4	9	27.27	7	21.21	8	24.24	9	27.27
Biacromial bi-iliac ratio	1	4	12.12	12	36.36	6	18.18	10	30.30
	2–3	15	45.45	19	57.57	17	51.50	17	51.50
	4	14	42.42	2	6.06	10	30.30	6	18.18
Strength	1	11	33.33	5	15.15	10	30.30	6	18.18
	2–3	16	48.48	18	54.54	14	42.42	20	60.61
	4	6	18.18	10	30.30	9	27.27	7	21.21

period. But in the quartile of greatest breast development all but one case were fat boys at the puberal onset, and even in the postpuberal period all but four cases. Without doubt, boys who experienced an early adolescent fat period tended to have more marked breast development during the fat period and to maintain this relative position after that period was over.

All the boys who rated highest in breast development had obvious localized subcutaneous tissue, but there were significant differences among them in the development of the nipples and areolae. Ten of them (nine of whom were fat boys) followed the accepted male pattern of small nipples surrounded by small pigmented areolae. Six followed a more feminine pattern of larger nipples and larger, less evenly pigmented areolae. These latter were all boys who had an early adolescent fat period.

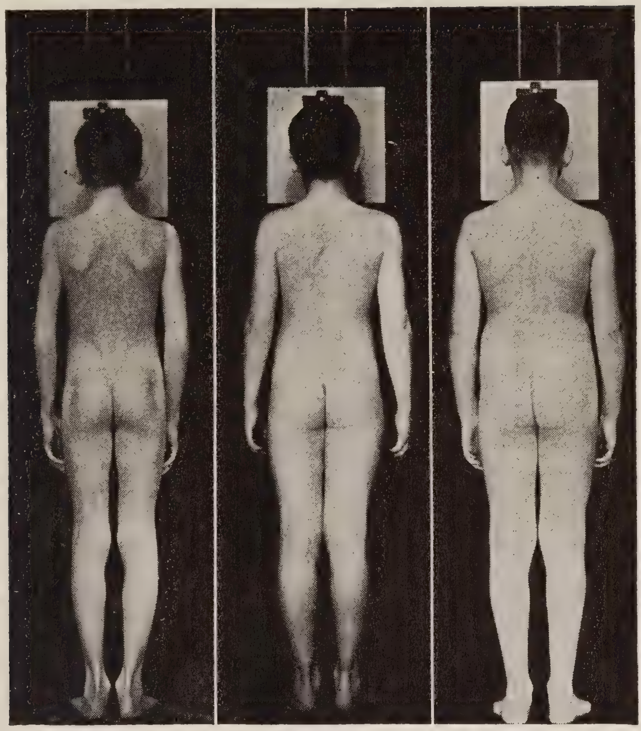
From our data we are unable to determine whether or not there was actual increase in mammary gland tissue as described by Jung and Shafton [8] or whether there was merely localized increase of fatty tissue as Hilda Bruch concluded.[9] The fact that there were definite differences in nipple and areolar development may have meant that in some of our boys such glandular involvement was present while in others it was not. In any case, marked localized fat increase is a recognized component of breast development and may of itself be a symptom of male-inappropriate growth.

However, no matter what may be the biological cause, there are emotional hazards for any boy in our culture whose chest contours suggest those of the other sex.

Simulation of the female girdle pattern of fat distribution. During the second decade of life nearly all girls tend to acquire increased fat padding around the lower part of the trunk and the upper parts of the thighs. For them this phenomenon is accepted as part of sex-appropriate maturation. Probably at least fifty per cent of boys experience some girdle-fat increase at a corresponding stage of development. When it becomes conspicuous it may seem to simulate the female pattern.

From careful inspection of our photographs we divided the 66 cases at the onset of the puberal period and in the postpuberal period into three groups: (1) the 16 cases (24.24 per cent) which showed the most obvious fat accumulation in the girdle area; (2) the 16 cases (24.24 per cent) which showed the least obvious; (3) the remaining 34 cases (51.52 per cent) which constituted the middle group. In Figure 171 we show one specimen from each group, rated at the onset of the puberal period.

The relation of fat accumulation simulating the female girdle pattern to the incidence of the early adolescent fat period among our boys is summarized in Table 107. None of the boys who experienced an early adolescent fat period was in the lowest quartile for girdle accentuation at either



Case 92 **Case 218** **Case 88**

FIGURE 171. Photographs of three boys who at the same stage in height development (b) represented varying degrees of fat accentuation in the girdle areas. Case 92 had no surplus fat over hips, lower abdomen, and buttocks. Case 218 had an average amount. Case 88 showed girdle fat somewhat resembling the female pattern as to amount and distribution. Accumulation of girdle fat was characteristic of boys while they experienced an early adolescent fat period, and they tended to retain fat in this area into the postpuberal period.

the puberal onset or in the postpuberal period. But these fat boys made up the whole of the upper quartile at onset and constituted all but two in the postpuberal period. The accumulation of fat in the girdle zone was certainly characteristic for boys while they were in an early adolescent fat period, and these boys tended to retain more fat around the hips in the postpuberal period than did those who had not manifested an obvious early adolescent increase. However, as the boys developed into the postpuberal period, even those with relatively more girdle fat appeared less sex-inappropriate than they had previously.

Simulation of the female pattern of thigh-leg configuration. Sex-linked differences in thigh-leg configuartion become more obvious during adolescence. Relative increase of bony, muscular, and fascial components is characteristic for boys; relative increase in subcutaneous tissue for girls.

The greater relative hip breadth of girls and the relative shortness of their legs tend to give the thigh-leg alignment something of a genu valgus (knock-kneed) pattern, whereas in boys the skeletal and muscular development during adolescence tend to give the thigh-leg alignment something of a genu varus (bowlegged) pattern.

Within our sample of boys during the adolescent period the photographs show considerable variation in thigh-leg configuration. After inspection we divided the photographs into three groups, separating the 16 (24.24 per cent) which showed greatest similarity to the female configuration and the 16 (24.24 per cent) which showed least similarity from the remaining 34 (51.52 per cent) lying between these extremes. This was done from photographs taken at the onset of the puberal period and during the postpuberal period. In Figure 172 we show photographs representative of the three groups as determined at b.

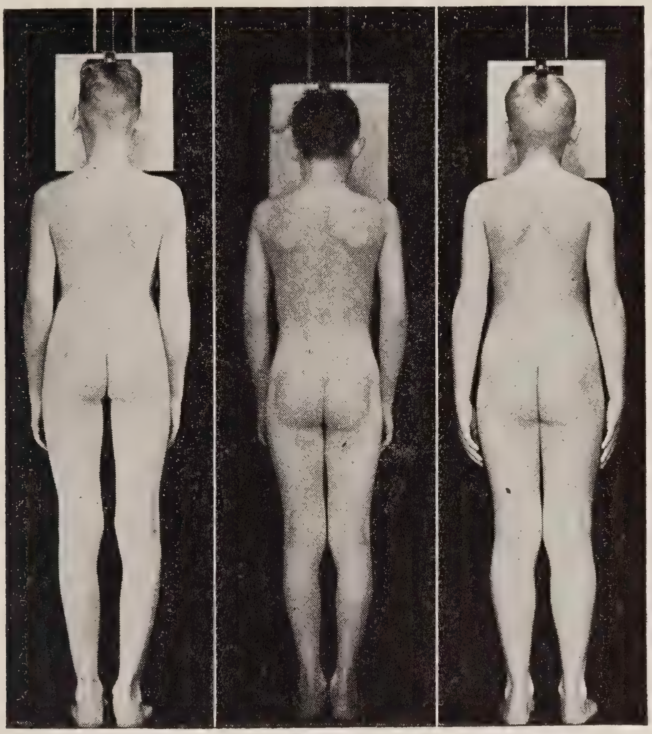
In Table 107 will be found the summary of relations between the incidence of early adolescent fat increase and the incidence of male-inappropriate thigh-leg configuration. There were a few fat boys at both the puberal onset and the postpuberal point who were among those whose legs and thighs showed the least similarity to the feminine type of configuration. But among the sixteen boys whose configuration was most feminine in type, fifteen were fat boys at onset and fourteen at the postpuberal point.

From this analysis it is obvious that boys who pass through an early adolescent fat period tend at that time and for some years afterward to have thigh-leg configuration which shows greater similarity to the female stereotype than does that of boys who do not have such a fat period.

Simulation of the female pattern of body hair distribution. The development of pigmented body hair occurs in both sexes during adolescence. But whereas in girls this development tends to be limited to the pubic and axillary regions, in boys it tends to spread over the areas adjacent to the pubic escutcheon, to appear on the chest, on the face, and sometimes over the limbs.

In our culture hairiness of body carries with it the implication of maleness and, during adolescence, marked retardation of the appearance of pigmented body hair and facial hair often disturbs boys and their parents.

In order to gain some insight into whether there is any relation between the incidence of an early adolescent fat period and lack of masculinity in body hair, we again divided the 66 boys into three groups approximating the quartile distribution. Our criterion was a combination of the pubic hair rating [10] and the amount and distribution of extrapubic pigmented hair as shown by the serial photographs. In Figure 173 we show the photographs of three boys in the postpuberal period to represent the 24.24 per cent

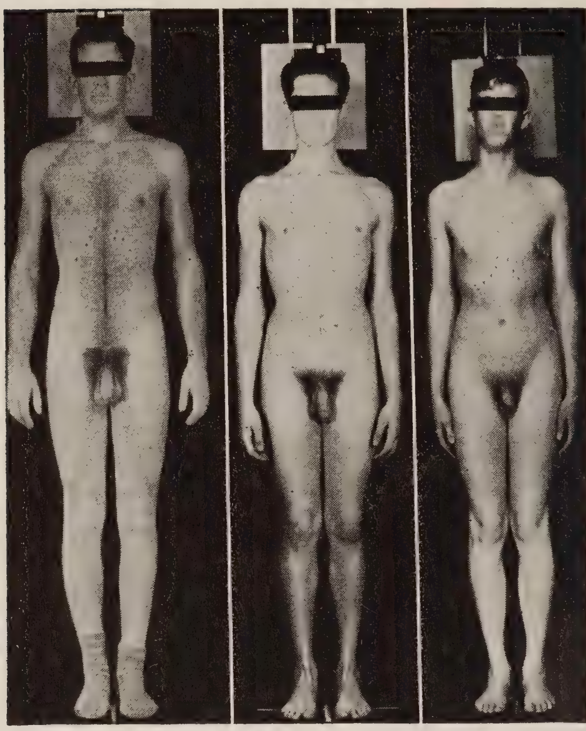


Case 50 **Case 64** **Case 250**

FIGURE 172. Photographs of three boys who at the onset of the puberal period represented varying thigh-leg configurations. Case 50 showed the accepted characteristic male pattern displayed by about 25 per cent of our cases. Case 250 showed a pattern which suggested female characteristics as found in about 25 per cent. Case 64 represents the intermediate group of about 50 per cent. All three were among those who had an obvious early adolescent fat period. In general, such boys have thigh-leg configurations which are similar to the female stereotype both during the fat period and for some years afterward.

who were most male-appropriate, the 24.24 per cent who were least male-appropriate, and the 51.52 per cent who fell between these extremes.

In Table 107 we have summarized the relation between the incidence of an early adolescent fat period and the occurrence of male inappropriateness of body hair development. At the puberal onset there was a slight tendency for these fat boys to be retarded in body hair development, but the most significant fact is the similarity of their numbers in the two extreme quartiles. In the postpuberal period there was little evidence that they differed in their distribution from those who did not have a fat period. From this analysis we conclude that there is a slight tendency for early adolescent fat increase to be associated with delayed and less extensive distribution of body hair at that time. In only two or three cases did we find



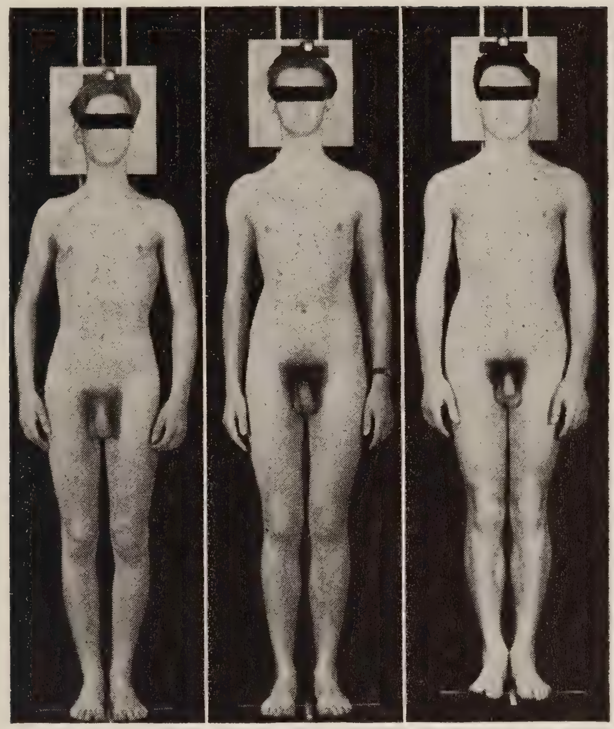
Case 234 Case 106 Case 58

FIGURE 173. Photographs of three boys with an early adolescent fat period who in the postpuberal period represented varying patterns of body hair development. Case 234 was among the 25 per cent with obviously male-appropriate hair development. Case 58 was among the 25 per cent whose body hair development suggested the female pattern. Case 106 represents the intermediate 50 per cent. There is a slight tendency for boys who experience an early adolescent fat increase to have delayed and somewhat less extended distribution of body hair during adolescence than other boys.

boys whose body hair distribution approximated the female pattern. These boys all had an early adolescent fat period.

Noticeably small diameter of the glans penis. There is widespread belief that unusually small male genitalia imply some degree of sex-inappropriate development. During the period when rapid growth of penis and testes usually occurs, any marked retardation of such growth may cause embarrassment and uneasiness to the boy involved.

By comparative analysis based on the inspection of their photographs we divided our sample into three groups by the method already described. The coronal diameter of the glans penis was used as the basis of comparison. Representatives of the three groups are shown in Figure 174.

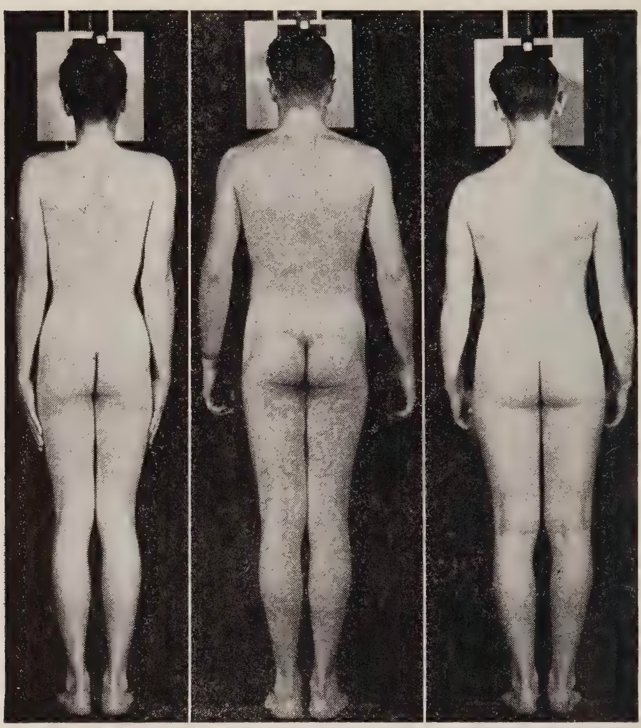


Case 24 **Case 84** **Case 292**

FIGURE 174. Photographs of three boys who in the postpuberal period showed obvious variation in glans penis diameter. Case 24 was among the 25 per cent with the greatest diameter. Case 292 was among the 25 per cent with the least diameter. Case 84 represented the intermediate 50 per cent. All three boys had an early adolescent fat period. In general, there seemed to be no positive association between the size of glans penis and the occurrence of the early adolescent fat period. (The foreskin gives an illusion of increased glans penis diameter in the photograph of Case 292.)

In Table 107 the relations of glans penis diameter at b and at d + 3 to the occurrence of early adolescent fat increase is indicated. There appeared to be no positive association either at the puberal onset or in the postpuberal period between size of glans penis and the occurrence of the early adolescent fat period.

Low biacromial/bi-iliac ratio. The sex-linked difference in relative breadth of shoulders and hips is usually increased during adolescence. During the latter half of the puberal period and continuing through the postpuberal period rapid growth in shoulder width is appropriate for boys, while rapid increase in hip width is characteristic for girls. The contrast in body-build appearance is partly due to differential skeletal growth and partly to differential subcutaneous tissue development. A low biacromial/



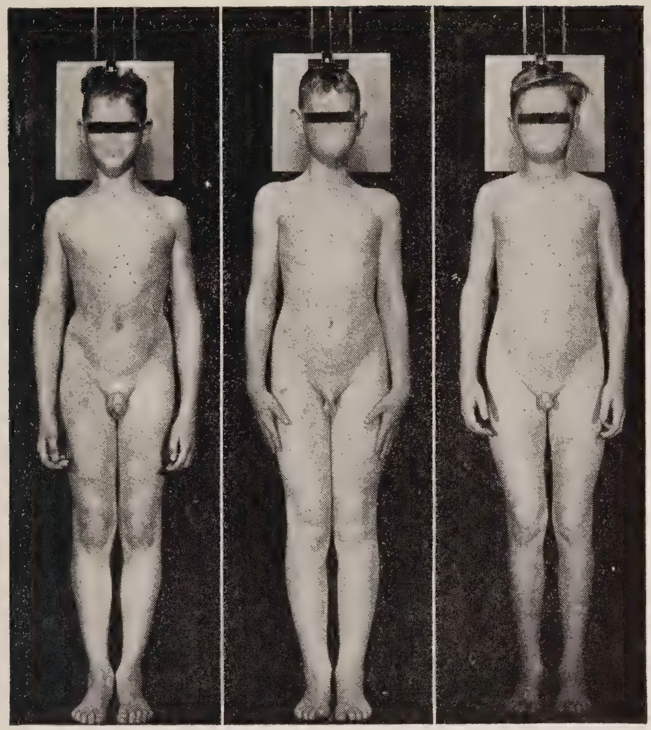
Case 78 **Case 224** **Case 18**

FIGURE 175. Photographs of three boys whose measurements in the postpuberal period showed significant variation in biacromial/bi-iliac ratio. Case 78 was among the 25 per cent with the highest ratio. Case 224 was close to the median for the group. Case 18 was among the 25 per cent with the lowest ratio. All three of these boys experienced an obvious fat period in early adolescence. There was a strong tendency for boys to have relatively narrow shoulders and wide hips during the adolescent fat period and a less marked but positive tendency to continue this more feminine type of build into the postpuberal period.

bi-iliac ratio in a boy may draw unfavorable comment with the implication that it is male-inappropriate.

Using the biacromial/bi-iliac ratios at the onset of the puberal period (b) and at d + 3 in the postpuberal period, we segregated the 16 cases (24.24 per cent) with the highest and the 16 cases (24.24 per cent) with the lowest ratios from the remaining 34 cases (51.52 per cent) and analyzed the relation of the three groups to the incidence of obvious early adolescent fat increase. Photographs of representatives of the three groups as determined in the postpuberal period are shown in Figure 175.

In Table 107 we have summarized the relation of low shoulder-width/hip-width ratio to the occurrence of the fat period. As will be seen, there was a strong positive relation at the time when the fat increase was occur-



Case 184 **Case 120** **Case 244**

FIGURE 176. Photographs of three boys taken at the onset of the puberal period. All three had an early adolescent fat period. Case 184 was among the strongest 25 per cent both at b and at d + 3. Case 244 was among the weakest 25 per cent at both times. Case 120 was among the intermediate 50 per cent at both times. In our sample boys with an early adolescent fat period were somewhat more apt to be strong than boys who did not show this phenomenon.

ring, and a definite, though less marked, tendency for fat-period boys to continue as relatively narrow-shouldered, broad-hipped specimens in the postpuberal period.

Low achievement in tests of muscular strength. For growing boys increase in muscular strength ranks high as assurance that their development is sex-appropriate. With but few exceptions our boys were more interested in the strength tests than in any other items, and at each examination throughout the seven years they made every effort to better their previous achievement. During the prepuberal period and the early part of the puberal, the girls were interested in their increasing strength, but later in adolescence many of them ceased to gain without apparent regret. Indeed, it was evident that some of them deliberately refrained from putting forth their best effort. It seems safe to conclude that among the adoles-

cents themselves achievement in tests of muscular strength was definitely male-appropriate.

In Figure 176 we show photographs of three boys who represent, respectively, the 16 strongest (24.24 per cent), the 16 weakest 24.24 per cent), and the 34 (51.52 per cent) who were intermediate at the onset of the puberal period. The scores of the combined tests of muscular strength were used as the basis of classification.[11]

Table 108 INCIDENCE OF FOURTH-QUARTILE RATINGS IN SEX-INAPPROPRIATE CHARACTERISTICS IN BOYS WITH AN EARLY ADOLESCENT FAT PERIOD

*Number of Items in Which Boy Rated in Fourth Quartile**	*Cases at b*		*Cases at d + 3*	
	Number	Per Cent	Number	Per Cent
0	6	18.18	2	6.06
1	5	15.15	8	24.24
2	8	24.24	4	12.12
3	4	12.12	9	36.36
4	4	12.12	1	3.03
5	2	6.06	4	12.12
6	2	6.06	1	3.03
7	2	6.06	0	0
Total	33	99.99	33	99.99

* Fourth quartile designated the 24.24 per cent of cases with most sex-inappropriate characteristics.

The relation of early adolescent fatness to strength at b and at d + 3 is shown in Table 107. It is interesting to note that both while they were in the fat period and subsequently during the postpuberal period these boys showed a definite tendency to be stronger than their fellows.

Individual variations in the male-inappropriate syndrome. Among the 33 fat boys there were wide differences in the number of characteristics on which they received a fourth-quartile male-inappropriate rating. Thus, during the fat period there were six boys who were not rated extremely high in any of the sex-inappropriate items, while there were two boys so rated in all seven of the items. During the postpuberal period there were two boys who received no extremely high sex-inappropriate ratings and none who was so rated in all seven items. Table 108 gives the incidence of fourth-quartile ratings in sex-inappropriate characteristics. At the puberal onset almost four fifths of the fat boys (79.69 per cent) were in the fourth quartile in from one to three items; about one fifth (21.31 per cent) received the extreme rating on four to seven items. By the time they reached the postpuberal period, 84.82 per cent were rated in the fourth quartile in from one to three items; 15.18 per cent in four to six items.

There was only one case (Case 8) who had no rating in the fourth quartile at either the puberal onset or the postpuberal point. He was a boy in whom the adolescent fat period was mild and short. There was no boy who was in the fourth quartile on all seven items at both points, but one boy (Case 58) was in the fourth quartile on seven items at the puberal onset and five items at the postpuberal point. Case 36, another extreme case, was in the fourth quartile on six and five items, respectively; Case 146 on five and six items, respectively.

SIMILARITIES AND DIFFERENCES AMONG INDIVIDUALS

Only through detailed study of the several photographic series, as well as of the measurements, can one grasp something of the qualitative and quantitative differences in growth process among the boys who were alike in having an early adolescent fat period. Some idea of the variation may be gained from the following summaries and the accompanying reproductions of the photographs.

Cases 18 and 88 (Figures 177a and b) present interesting similarities and differences. Each passed through an obvious fat period which peaked soon after the onset of the puberal growth period for height. Their heights at corresponding developmental points were about the same. Both showed a consistent tendency toward marked subcutaneous tissue development throughout adolescence. Both commenced their puberal growth period for height at about the same age.

In shoulder/hip width ratio, however, they were very different. Case 18, from the onset of the puberal period (b) to Point d + 3 in the postpuberal period, was among the quartile group with the highest ratio in this respect, while Case 88 consistently remained in the lowest quartile group. In stem length/height ratio, also, these two boys showed obvious difference, Case 18 having a relatively long trunk while Case 88 had relatively long legs. Throughout adolescence the somatic growth of Case 88 was distinctly less sex-appropriate than that of Case 18.

Cases 250 and 66 (Figures 178a and b) illustrate the fat period in two boys whose propensity toward subcutaneous storage of adipose tissue became strikingly different during adolescence. At the third examination before the onset of the puberal period both were among the fourth-quartile group (highest) of the sample as distributed according to subcutaneous tissue thickness. Both maintained the same relative position at the onset (b), although in actual measurement Case 66 exceeded Case 250 by at least 25 per cent. (See distribution in Figures 133b, c, d, and e on pages 254-55.) But at the end of the puberal period Case 66 remained the outstanding example of massive fat storage, while Case 250 was somewhat below

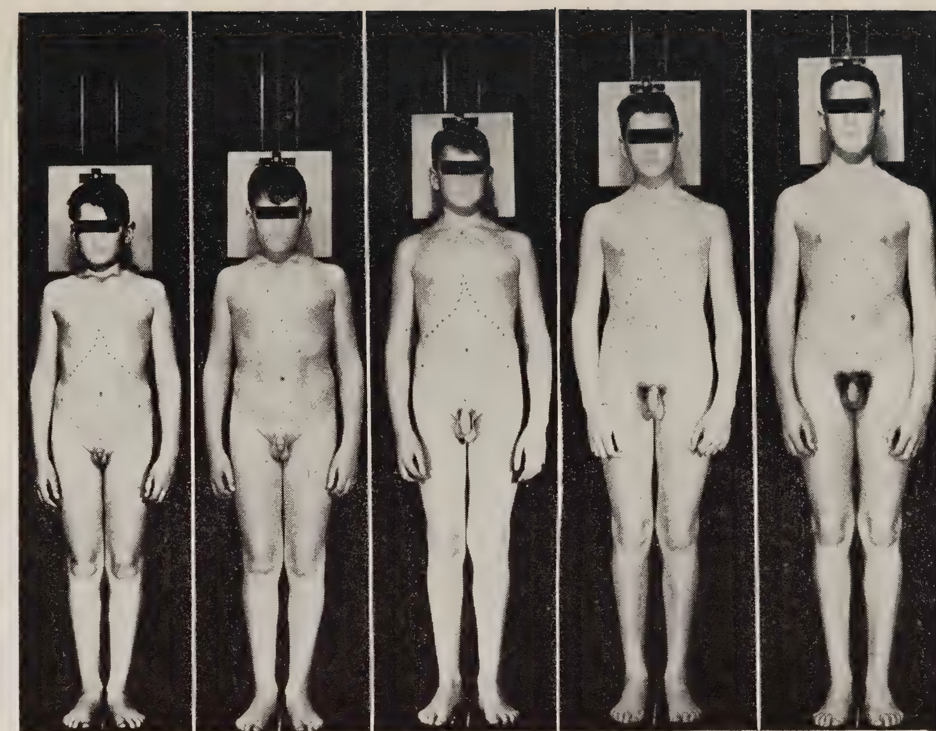
C.A. 11.9 13.0 14.0 15.1 16.2

b d

Fat period apex

Case 18

FIGURE 177a.

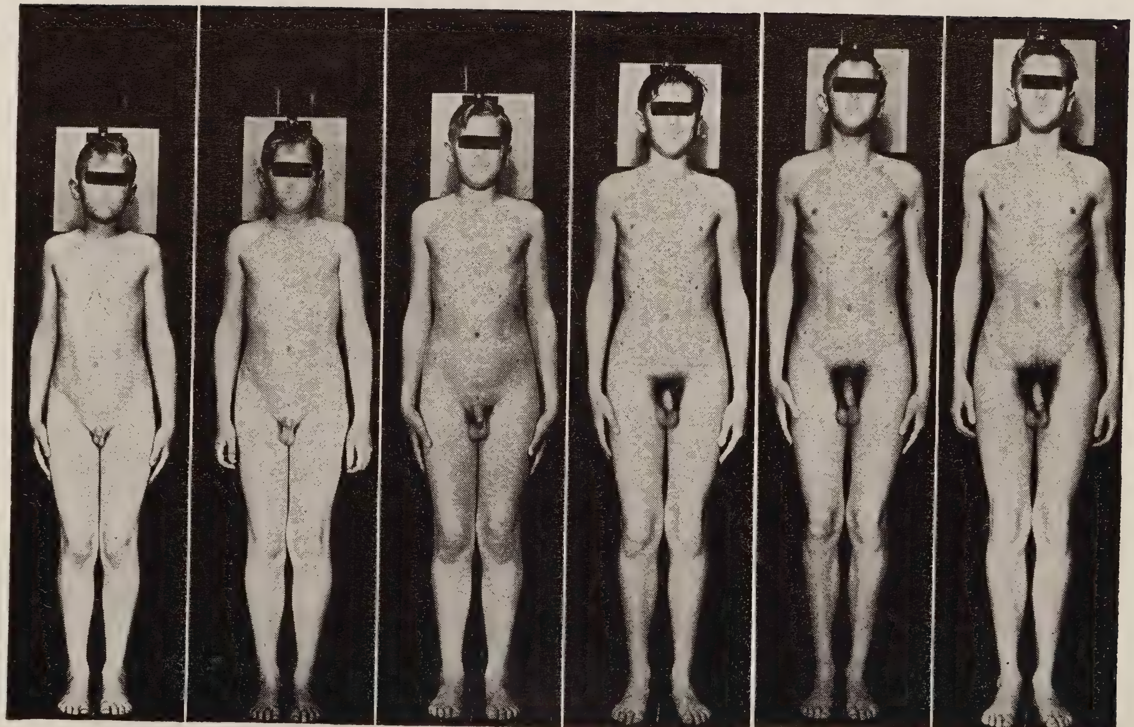


C.A. 11.3 12.3 13.3 14.3 15.3

b Fat period apex d

Case 88

FIGURE 177b.



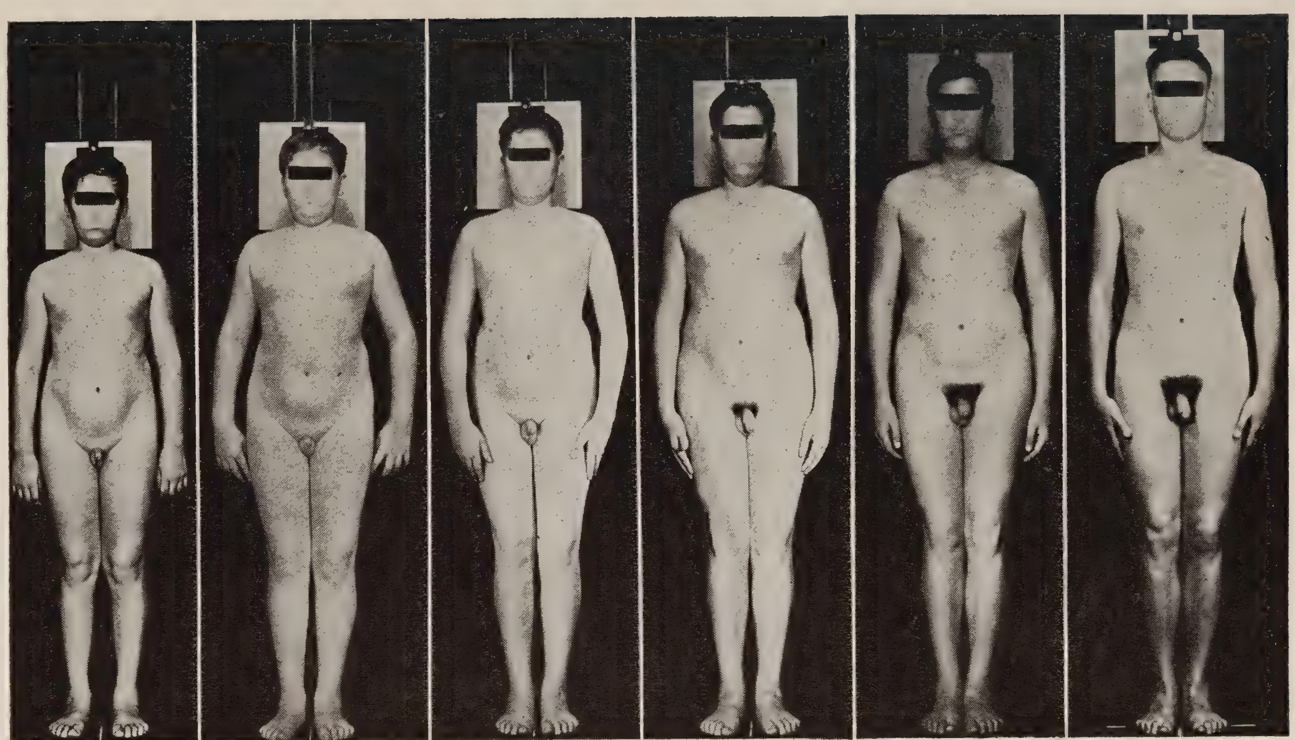
C.A. 10.8 11.8 12.7 13.7 14.7 15.7

b d

Fat period apex

Case 250

FIGURE 178a.



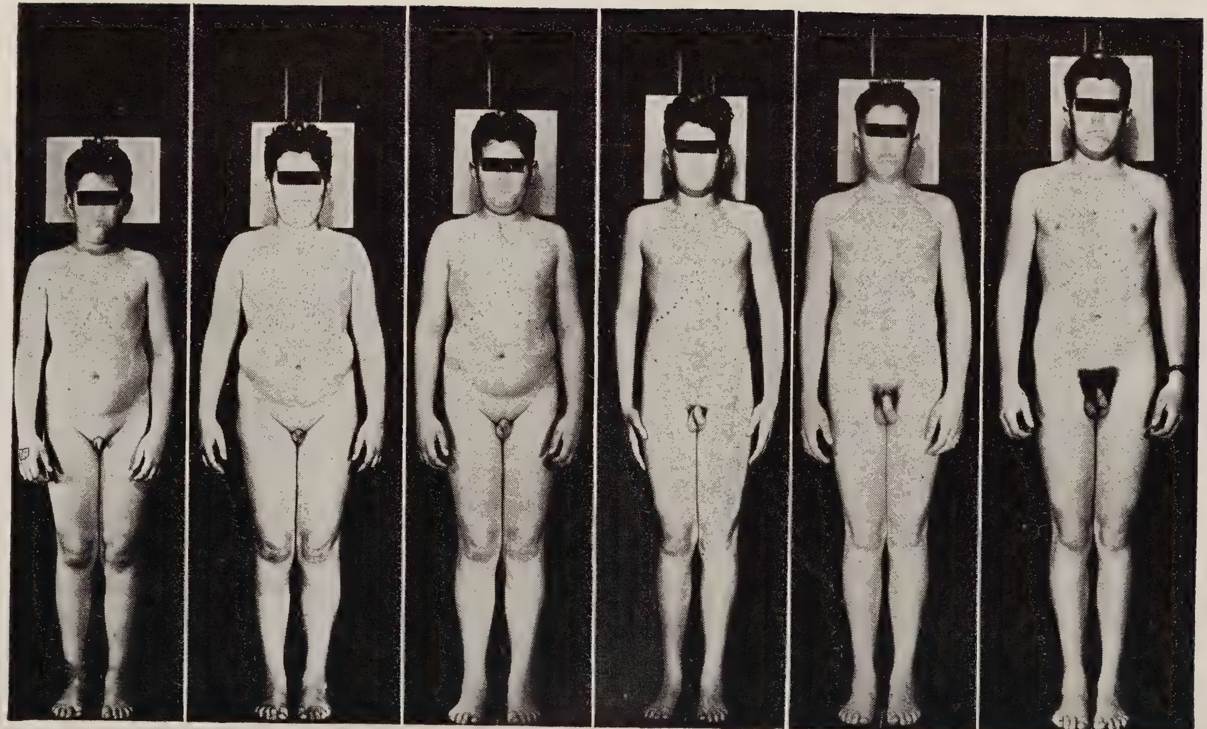
C.A. 11.8 12.8 14.0 15.0 15.9 17.0

b d

Fat period apex

Case 66

FIGURE 178b.

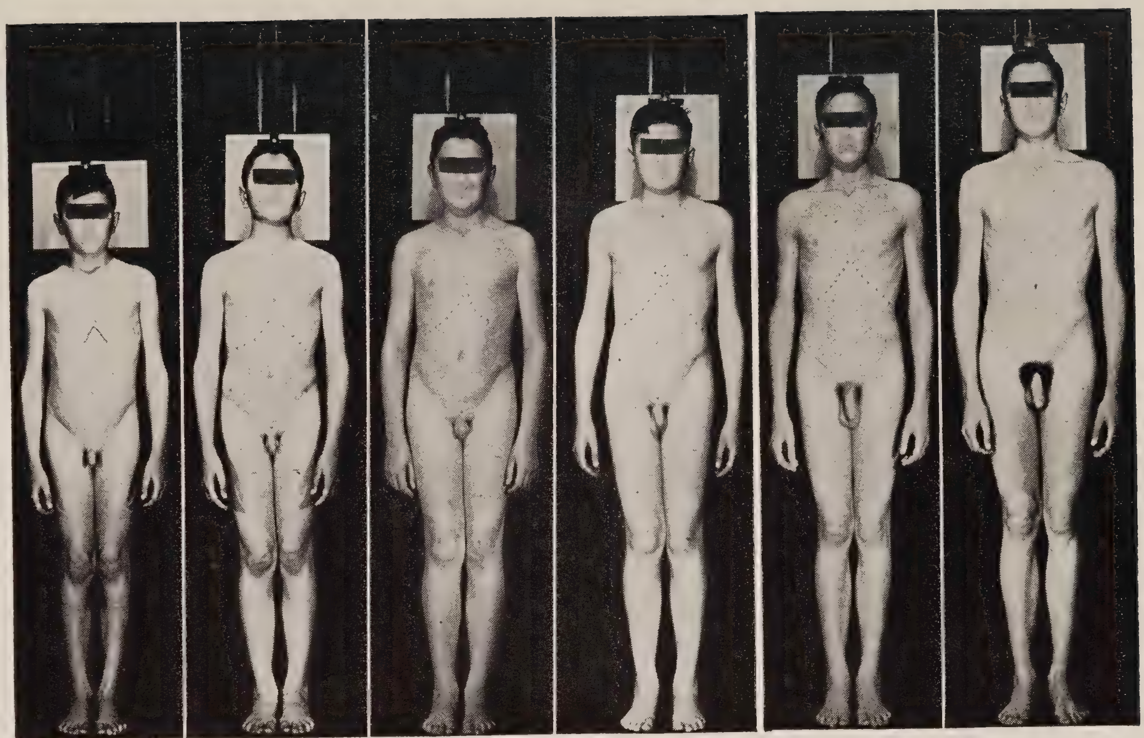


C.A. 10.6 11.6 12.6 b 13.6 14.7 15.6 d

Fat period apex

Case 224

FIGURE 179a.



C.A. 10.6 11.6 12.7 13.7 b 14.6 15.6 d

Fat period apex

Case 236

FIGURE 179b.

the median for the group. At the third examination after the end of the puberal period (d + 3) Case 66 showed much less fatty tissue but still ranked as the fattest in the sample; Case 250 fell into the first-quartile group.

It will be noted that Case 250 commenced his puberal height growth at 11.55 years, while Case 66 started about two years later at 13.65 years. For Case 66 the fat period peaked late in the prepuberal phase; for Case 250 it peaked early in the puberal period. In sex-inappropriate syndrome traits Case 250 rated significantly higher in early adolescence, but after the puberal period Case 66 rated higher in most of them.

The two boys in Figures 179a and b (Cases 224 and 236) both had easily recognizable fat periods which peaked before the onset of puberal growth in height. Both were sex-appropriate in skeletal build and both ranked high in muscular strength until the postpuberal period, when Case 236 dropped below the median for the group. In their interests both were strongly male. Yet during the fat period both showed a tendency toward girdle adiposity and toward the female type of thigh-leg configuartion. As can be seen from the photographs, neither boy was retarded in pubic hair development. In the postpuberal period neither had particularly small genitalia.

The outstanding differences between Case 224 and Case 236 were in the timing of the fat period and the degree of fat increase which occurred. Note that for Case 236 the peak of fatness and the onset of the puberal spurt in glans penis growth (P_1) occurred at about the same time, whereas for Case 224 the fatness peak preceded the glans penis growth by about a year. Case 236 was not disturbed by the moderate transient fat increase which he experienced, but Case 224 was physically incommoded and psychologically disturbed by the very considerable amount of fat which he acquired.

Cases 164 and 90, shown in Figures 180a and b, illustrate differences rather than similarities except in one respect: each experienced a fat period which was unusually late in relation to other growth phenomena.

Case 164 showed no excess fat prior to nor following his relatively brief fat period, yet for a year or so he was quite fat. His thigh circumference measurement at age 13.2 years was greater than at any other examination from age 10.6 years to age 17.6 years, and at the fat peak he was rated definitely sex-inappropriate in five out of seven items. If he was disturbed by this rapid though transient metamorphosis he kept it to himself.

Case 90, on the other hand, was quite unhappy about the fat period, which peaked at about the mid-point of his puberal height growth, and was particularly sensitive concerning his breast enlargement. His parents

sent him to an endocrinologist for treatment, but after one injection the boy refused to return, and probably the definite fat recession which commenced six months later cannot be ascribed to specific therapy. From this boy's reaction one may hazard the guess that a delayed fat period occurring when other boys have outlived this inconvenience is particularly apt to cause emotional stress. This boy refused to complete the seven year series of examinations.

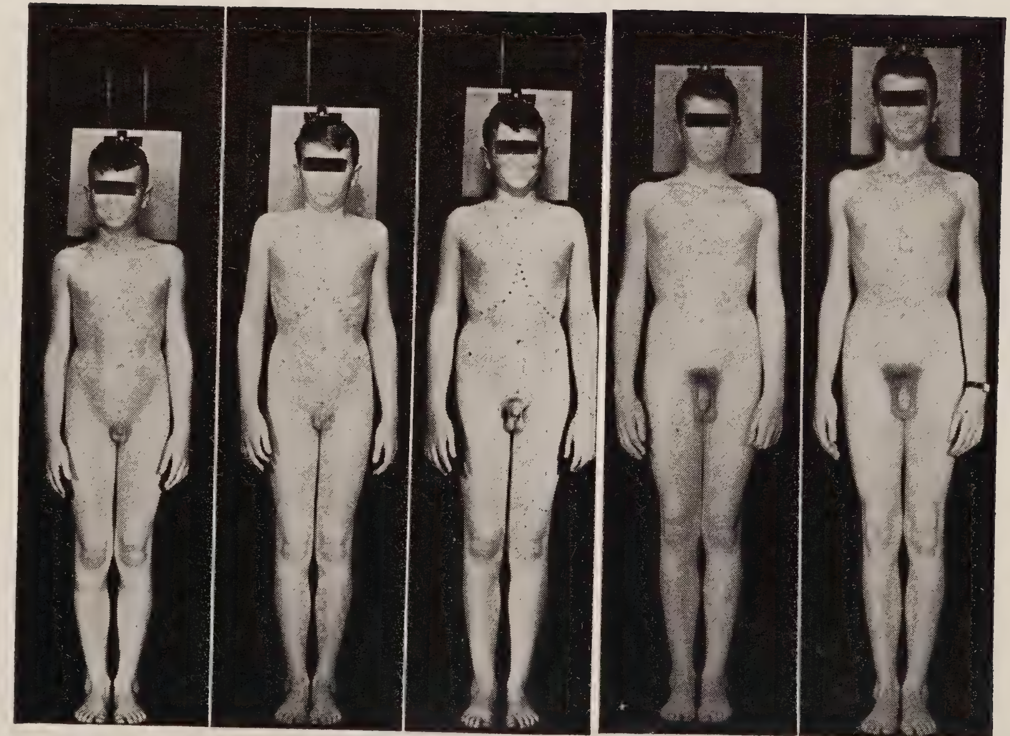
The contrast in growth pattern between Case 146 and Case 36 may be seen at a glance by looking at their photographs in Figures 181a and b. From the point of view of the investigator they illustrate the dangers of judging the somatic ensemble from the consideration of relative ratings on separate items without the synthesis which is an inherent advantage of visual appraisal.

Each of these boys passed through an obvious fat period. Ratings of sex-inappropriate body growth at the onset of the puberal period grouped them together as being among the 25 per cent showing the closest simulation to the female breast pattern, the female pattern of girdle fat, and the female thigh-leg configuration, and their measurements bracketed them among the 25 per cent with the lowest biacromial/bi-iliac ratio. Yet differences in timing, quantity, and total configuration combined to produce one boy (Case 146) who, even at the peak of his fat period, was very different from the others at the corresponding point in height development. Nor did the essential constitutional differences grow less as they grew older.

Case 146 was a relatively early developer; Case 36 was a late developer. The former started his puberal height growth at 12.2 years, the latter at 14.35 years. Case 146 started rapid glans penis growth at 11.9 years; Case 36 at 13.6 years. In pubic hair development Case 36 lagged more than two years behind Case 146. Although grouped together in our quartile distribution, there were significant quantitative differences between the two, not only in general subcutaneous tissue thickness but in the degree to which fat tended to localize in specific areas and in the ratio of shoulder width to hip width.

Case 146 was but slightly perturbed over his passing peculiarities, while Case 36 was for years defensive and unhappy over his body. Even late in adolescence, when he was no longer noticeably fat, and when his street clothes masked even the suggestion of sex-inappropriate body build, he retained the reserved and slightly defensive reaction which had emerged at the onset of the fat-period phenomenon.

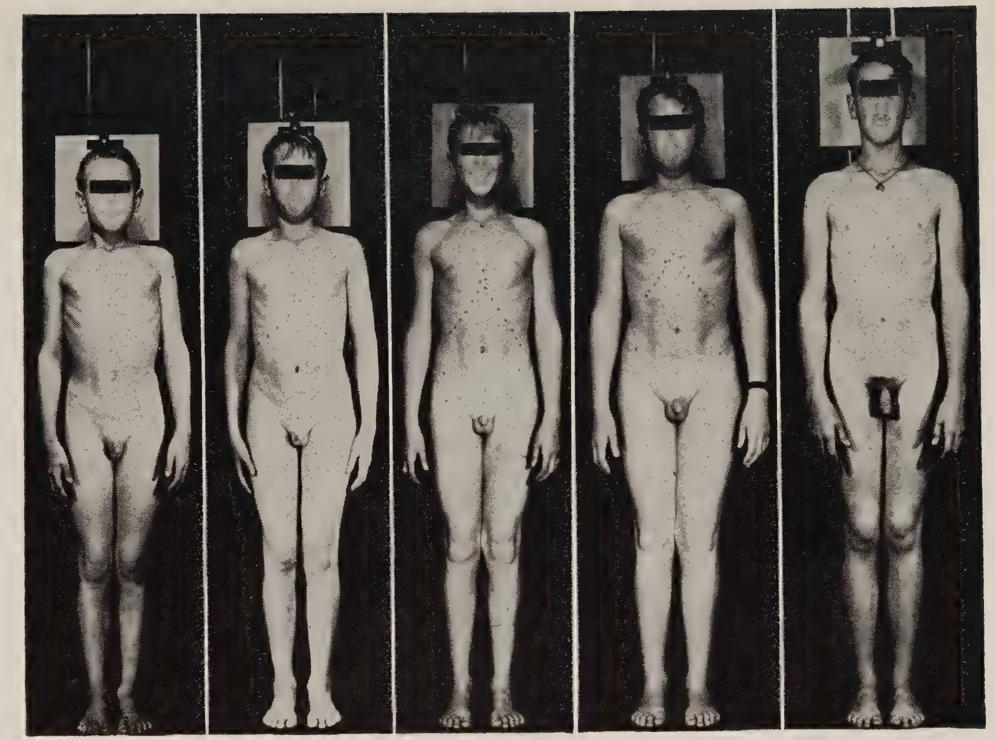
Case 118 is shown in Figure 182 because he illustrates the dramatic rapidity with which the redundant subcutaneous tissue of the early adolescent fat period may disappear without specific therapy and without any



Fat period apex

Case 164

FIGURE 180a.



C.A. 13.0 14.1 15.2 16.0 17.1

b

Fat period apex

Case 90

FIGURE 180b.

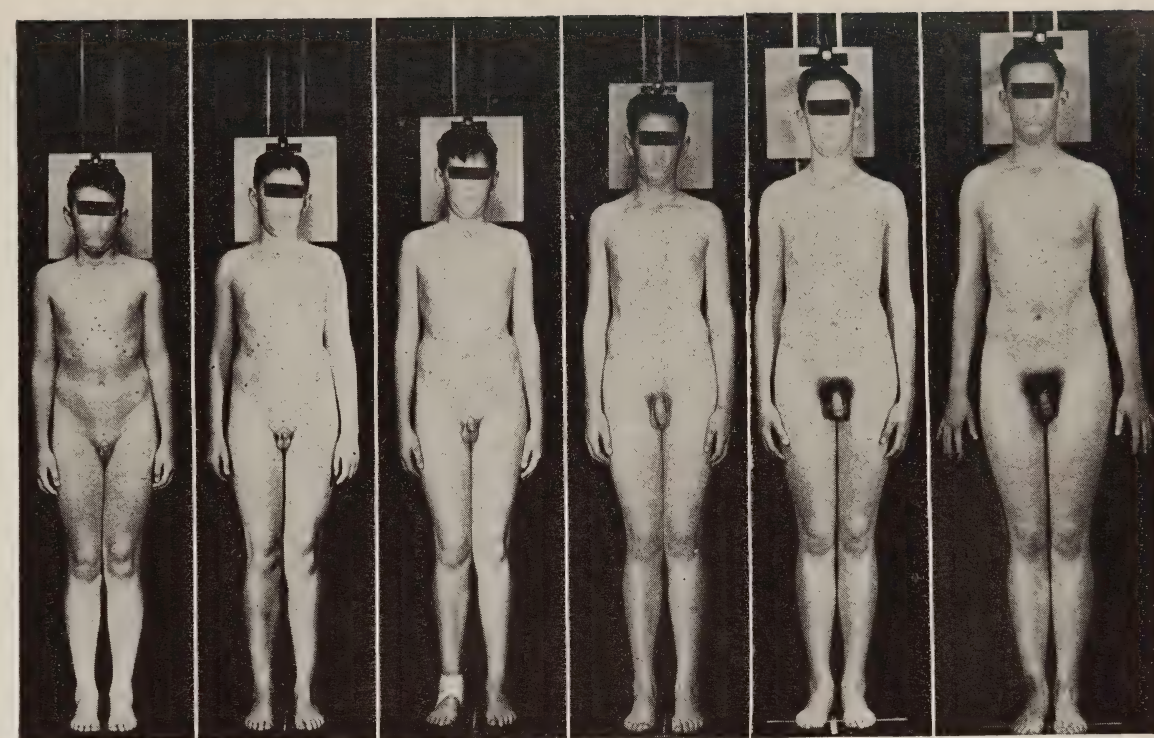
C.A. 10.9 11.9 12.9 13.9 14.9 15.9

b d

Fat period apex

Case 146

FIGURE 181a.



C.A. 12.6 13.6 14.6 15.6 16.6 17.6

b d

Fat period apex

Case 36

FIGURE 181b.

conscious change in diet. At the first examination (10.9 years) Case 118 already was in the fat period which became most evident at 11.9 years and was over by 13.0 years. Note the speed with which puberal height growth, genital development, and pubic hair development took place. There was a change in facial expression as the fat diminished. This case illustrates, also, the increase in rate of stem length growth occurring as the fat period phenomenon waned.

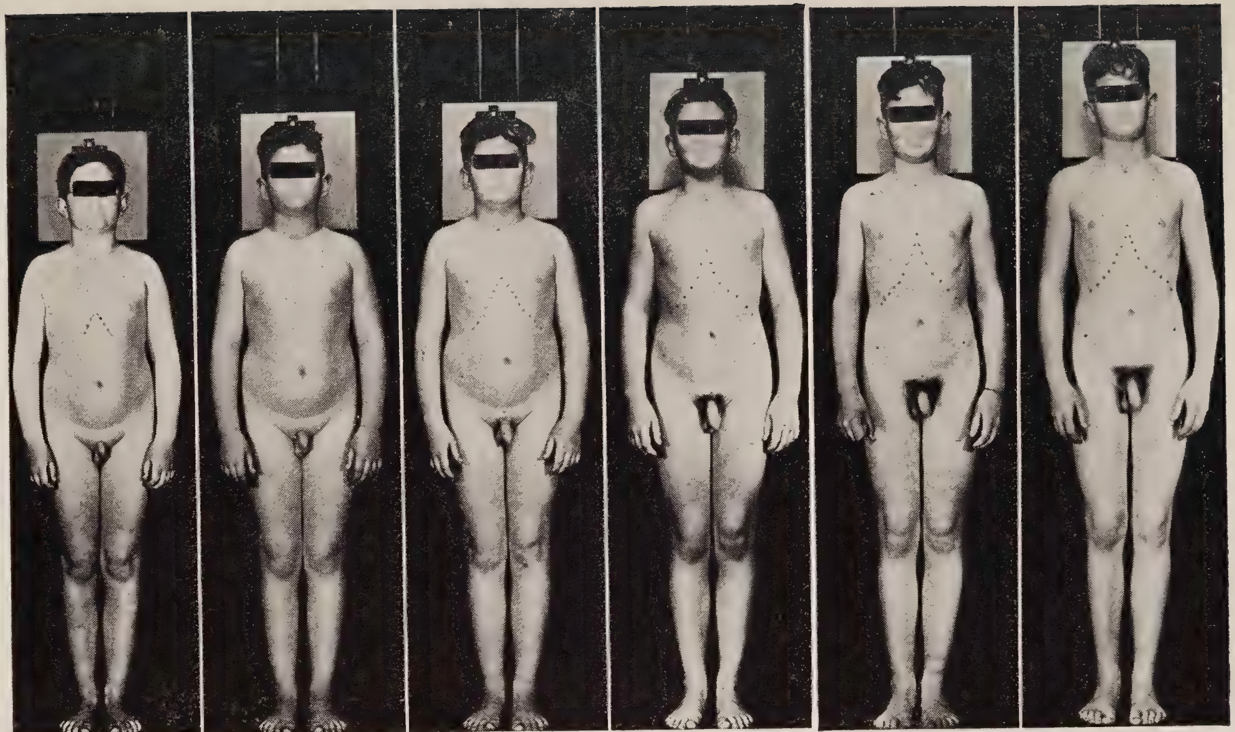
SUMMARY

Of the changes in thickness of subcutaneous tissue and of general adiposity which occurred in our adolescent boys the most common, most dramatic, and the psychologically most disturbing to them was a cycle of increase-decrease which centered at or near the onset of the puberal period for height and the onset of the puberal spurt in penis growth.

From an analysis of the serial measurements of 66 boys supplemented by inspection of their serial photographs, we found that about two thirds of our cases manifested this particular fat-period phenomenon.

The fat period varied somewhat in timing and duration and greatly in degree of peak intensity of fat growth. It occurred most frequently among boys with relatively low biacromial/bi-iliac ratio, with relatively high average subcutaneous tissue thickness, and with above average muscular strength; but it occurred sometimes in boys who had none of these characteristics. Its occurrence bore little or no relation to height, shoulder width, synchrony or asynchrony of growth, or precocity or retardation of general development, nor was it significantly related to persistent differences in size of genitalia.

Boys in whom the fat period was marked tended during that time to have conspicuous accumulations of fat around the nipples and over the abdomen, hips, and thighs. In some cases these specific contour accentuations, coupled with unusually low shoulder/hip ratio, and with retardation in genital growth, suggested male-inappropriate development. Except in a few cases, this impression was obliterated by the end of the postpuberal period. However, there was evidence that in such cases the early adolescent fat-period experience continued to affect personality development unfavorably for many years after the somatic stigmata had disappeared.



C.A. 10.9 11.5 11.9 12.5 13.0 13.6

b d

Fat period apex

Case 118

FIGURE 182

FOOTNOTES FOR CHAPTER XV

[1] In her illuminating studies of obesity in children, Hilda Bruch has referred to this early adolescent fat period, but only incidentally. See "Obesity in Childhood." *Am. J. Dis. Child.,* **58:**457–484.

[2] Cases found in Groups B, C, and D among our intensive sample of 67 boys.

[3] In ten cases the profiles indicated that the prepuberal onset of the fat period probably had occurred prior to the first examination.

[4] Bruch, *op. cit.,* found that obese children were above average in height for age.

[5] Case 130 was omitted because this boy's postpuberal development occurred at too late a chronological age to be included among our data.

[6] Quartile 1 included 16 cases (24.24 per cent); quartiles 2 and 3 together, 34 cases (51.52 per cent); quartile 4 included 16 cases (24.24 per cent).

[7] Examination consisted of inspection and palpation of the breast area.

[8] Jung, F. T., and Shafton, A. L.: "The Mammary Gland in the Normal Adolescent Male." *Proc. Soc. Exper. Biol. & Med.,* **33:**455–458, 1935.

[9] *Op. cit.*

[10] See Chapter XIV.

[11] See Chapter XIII.

Chapter XVI THE RHYTHM OF GROWTH DURING ADOLESCENCE

THE outstanding phenomenon of somatic growth during the period between childhood and adulthood is the puberal sequence of rapid increase followed by rapid decrease in the growth rate. In almost all growth velocity profiles the apex between acceleration and deceleration is an easily recognizable feature and has been used very generally as a reference point for estimating maturity.

But, as far as we are aware, little attention has been paid to the rhythmic alternation of accelerated growth and decelerated growth which occurs throughout adolescence and of which the puberal apex is but the most obvious feature.

As our profiles of growth velocity were extended from six month period to six month period during the seven year accumulative study, it became evident that the pattern of each profile was unique, but it also became evident that for many measurements in many individuals there was a strong tendency toward a systematic sequence of rise and fall in growth rate.

The identification of a general pattern of sequential growth rhythm will supply additional points of reference for the appraisal of the maturity of an individual as well as data pertinent to the process of human growth. Therefore, we present in this chapter our findings regarding the incidence, configuration, and timing relations of the pattern which we found together with the variations of the pattern in individuals.

Inasmuch as we had no premonition that such a pattern would emerge, the plan of data collection was not so suitable for this purpose as we might wish, particularly as regards the first and the last of the four phases described. It must remain for subsequent research finally to corroborate, modify, or disprove our hypothesis.

THE FOUR PHASE PATTERN

The four phase sequence which we found in the growth velocity profiles for our sample is illustrated by the generalized profiles of stem length, leg length, biacromial width, and bi-iliac width shown in Figure 183. These profiles are based upon the group average of timing and growth

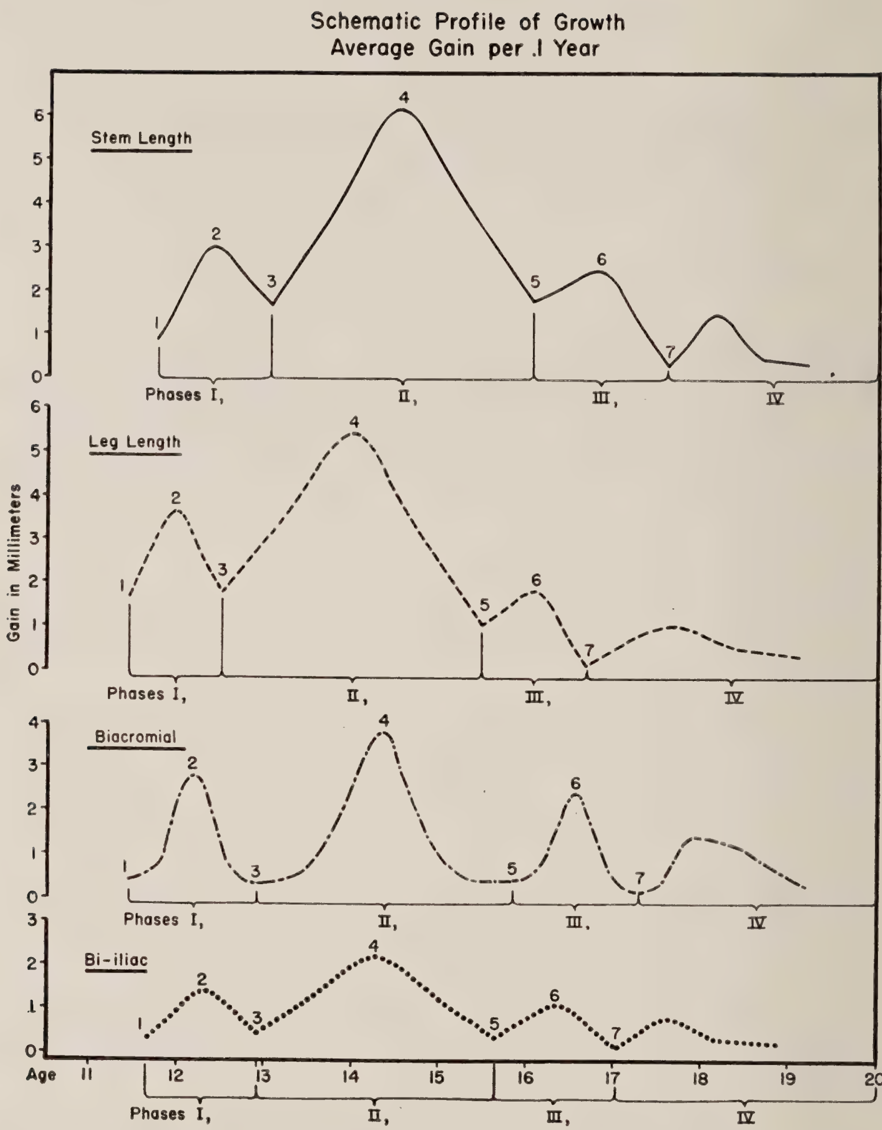


FIGURE 183. These four schematic curves for stem length, leg length, biacromial width, and bi-iliac width show the successive phases in the rhythm of growth during adolescence. The profiles represent the mean timing and growth rate values for our sample of boys. The Arabic numeral 1 indicates the point of transition between childhood and adolescence; the transition from adolescence to adulthood is beyond the range of our data. Points 3, 5, and 7 separate Phases I, II, III, and IV. Points 2, 4, and 6 indicate the peak growth rates for the first three phases. We have designated Phase I as prepuberal, Phase II as puberal, Phase III as postpuberal, and Phase IV as late adolescent.

Note the general configurational similarity among the four profiles and also the quantitative differences in timing and magnitude which distinguish them from each other.

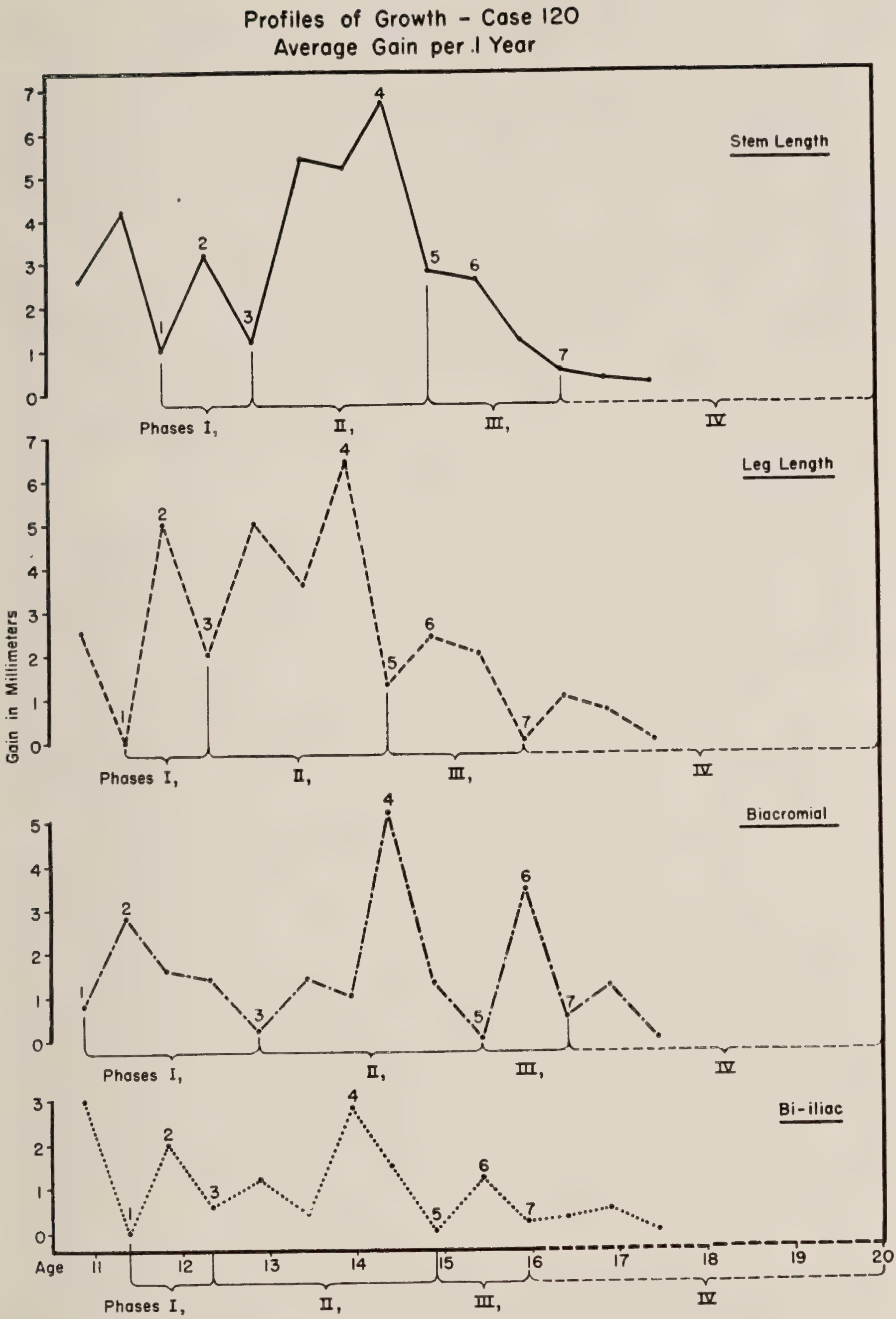


FIGURE 184. These four profiles show the rhythmic pattern of growth as it occurred in four aspects of development in the same boy (Case 120) during adolescence. In each profile Phases I, II, III, and IV are indicated, although only the first three of these phases and the early part of the fourth can be defined and described from the data collected in this study. The peaks of Phases I, II, and III are indicated by the Arabic numbers 2, 4, and 6, respectively. Arabic number 1 is at the flexion which separates adolescence from childhood; numbers 3, 5, and 7 indicate the flexions which separate the four phases. These profiles should be studied in relation to each other.

rate values at Points 1, 3, 5, and 7 and upon the growth rate values at Points 2, 4, and 6. The locations of these points for each individual were determined by inspection and comparison of his growth profiles for height, stem length, leg length, biacromial width, bi-iliac width, weight, and muscular strength.

In determining the location of the flexion points which define the several phases, advantage was taken of the strong tendency toward similarity of configuration among the several profiles for each individual. The unique characteristics of an individual boy's growth profile in stem length are, with but few exceptions, easily recognizable in his leg length profile, frequently apparent in his hip-width profile, occasionally quite clear in one or more of his other profiles.

It is important to emphasize here that *the phase points for each curve can only be determined with assurance by comparison with corresponding points in other growth curves for the same individual.* Such comparison makes it possible to distinguish between minor fluctuations in the growth curve and points of phase differentiation.

An individual's height growth profile is usually least likely to display his characteristic configuration (11 out of 54 cases) because of the strong tendency for the corresponding developmental points in leg length growth and stem length growth to occur at different times.

Of the four phases shown in Figure 183, Phases, I, II, and III fall well within the scope of our data. The early part of Phase IV is represented in many of our cases, but in no case do we have data for determining the time at which this phase ends.

It should be clearly understood that the profiles shown in Figure 183 *are schematic profiles to illustrate our hypothesis of rhythmic cyclical growth phenomena during adolescence.* They do not purport to be standards of optimal growth. Only rarely do they show obvious similarity to the actual individual profiles which have been presented in previous chapters of this book.[1]

THE PATTERN IN STEM LENGTH GROWTH

The growth phase pattern for stem length during adolescence is well illustrated by Case 120 in Figure 184. Comparison of this profile with the schematic profile for stem length in Figure 183 shows that in this particular boy the transition from childhood to the first phase of adolescence was well marked by a rapid deceleration of growth rate leading down to Point 1 at C.A. 11.85, which was a tenth of a year later than the group average (C.A. 11.75). Phase I for Case 120 (prepuberal phase) from

Point 1 to Point 3 is very similar in contour to its schematic counterpart, although the latter lasted three months longer (1.05 years : 1.30 years). During Phase II (puberal phase) from Point 3 to Point 5 this boy's acceleration in stem length growth was interrupted for six months just prior to reaching its apex. Such minor interruptions occurred in many of our cases, but, of course, they do not show in the smoothed schematic curve.[2] The apex velocity rate in stem length growth for this boy was 6.33 millimeters per .1 year, that for the group was 6.2 millimeters. The duration of Phase II for this case was 2.0 years which was considerably shorter than the group average (2.98 years). Phase III (postpuberal phase) from Point 5 to Point 7 was somewhat less marked for this boy than for many others.[3]

The growth velocity at Point 6 was 2.6 millimeters per .1 year as against 2.5 millimeters for the group, and the duration of Phase III was 1.5 years as against the group average of 1.57 years. At the close of Phase III (Point 7) this boy's rate of growth in stem length was .5 millimeter per .1 year; the average for the group was .3 millimeter per .1 year.

The phase which extends from Point 7 to the complete cessation of growth we have indicated in our schema as Phase IV, although the data from our sample do not extend for more than a year or so beyond Point 7. For the boy whose stem length profile is shown in Figure 184, growth in this dimension decelerated gradually to zero during the year immediately following Point 7. Whether he exhibited further stem length growth we do not know, but from what little data we have been able to gather from our sample and from the studies which have been made of growth in male college students, it seems probable that, for stem length, Phase IV may exhibit intermittent low velocity growth for several years. In any case, the profile for Phase IV shows characteristics which clearly distinguish it from the three preceding phases.

Among our sample there were 54 boys for whom the range of the data was sufficient to include Phases I, II, and III. Of the 54 stem length profiles 45 (83.33 per cent) showed a clear three phase pattern; 8 showed the general schematic arrangement but left some doubt as to one or two of the flexion points; in one profile the pattern of the first three phases, if present, was so distorted as to be unrecognizable. In Figures 185a and b we show as examples five profiles which vary widely in configuration, but in each of which the first three phases of adolescent growth are easily discernible. In Figure 185c are examples of three profiles which leave some doubt as to the exact location of some of the flexion points which separate the phases.

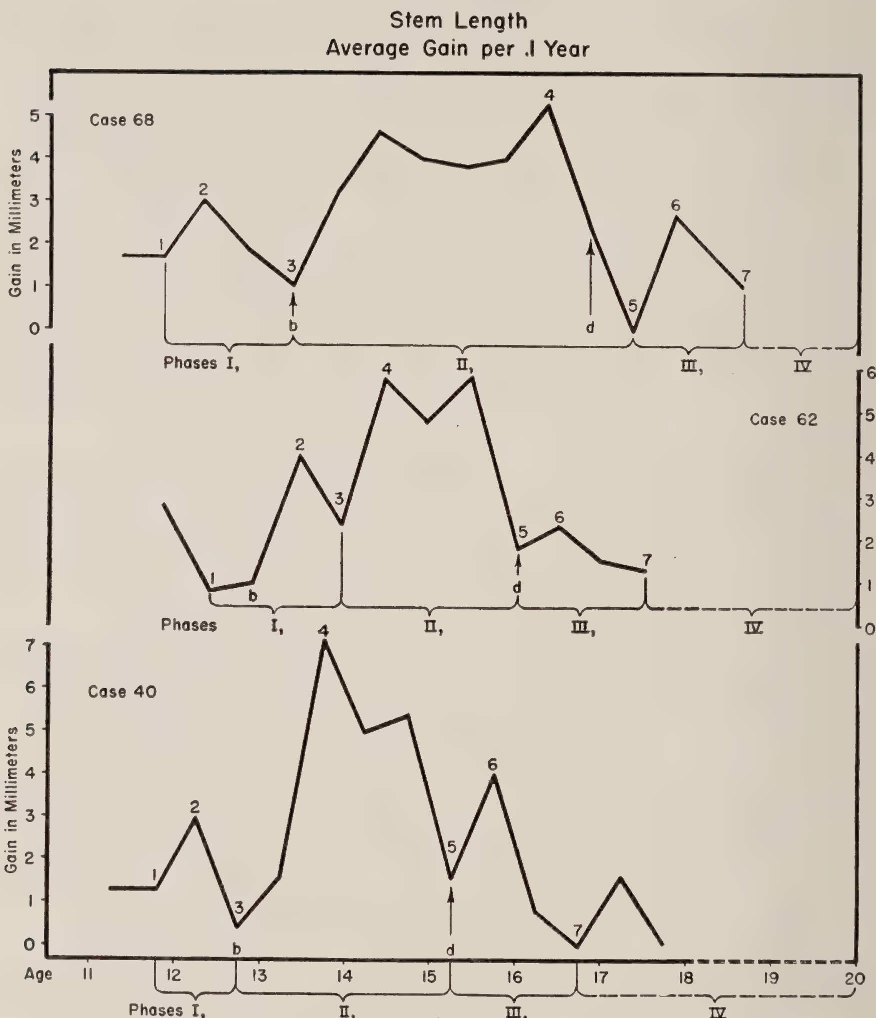


FIGURE 185a.

THE PATTERN IN LEG LENGTH GROWTH

The phase pattern for leg length growth during adolescence is illustrated by the schematic profile in Figure 183 and by the specimen individual profile for Case 120 in Figure 184. Comparison of these two profiles brings out the characteristics of leg length growth peculiar to this individual boy and also some of the characteristics which serve to distinguish leg length phase patterns from phase patterns of other measures.

It will be noted that for this boy Phase I of leg length growth commenced at C.A. 11.4, which was almost identical with the mean age for

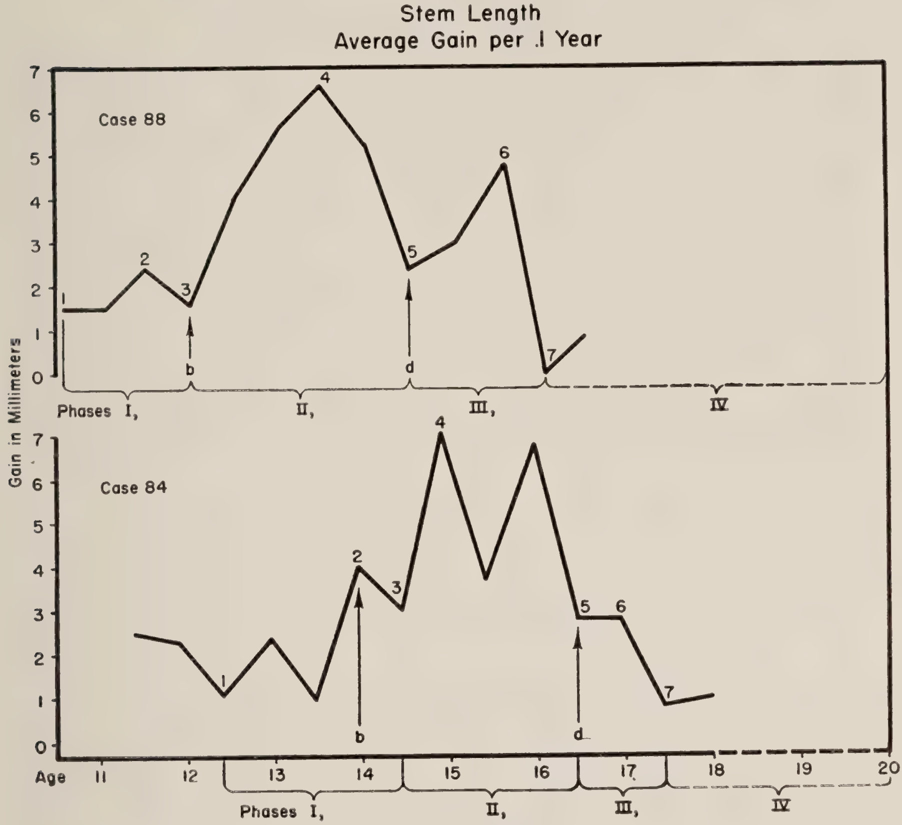


FIGURE 185b.

FIGURES 185a and b. The five stem length growth profiles in these figures illustrate the clear-cut three phase configuration pattern which was shown by 83.33 per cent of the cases. These five profiles have been selected because they exemplify individual differences in timing and relative magnitude of stem length growth in the three phases. Cases 40 and 62 were short boys, Case 84 was tall, and Cases 68 and 88 were of medium height. Note the two peaks in the prepuberal phase (Phase I) for Case 84. This variation is apt to occur in boys whose maturation progresses at a relatively slow rate. The puberal period for *height* occurred between *b* and *d*.

the group (C.A. 11.45). But for this case Phase I was much more prominent than the mode, the growth rate at Point 2 was 5.0 millimeters per .1 year when the group averaged 3.62 millimeters per .1 year. In our specimen case Phase I was slightly shorter than average (.95 year : 1.05 years). Phase II starts .15 year earlier in the specimen than in the schematic profile (C.A. 12.35 : C.A. 12.50) and is almost a year below average in duration (2.05 years : 2.99 years). Phase III starts sooner than average (C.A. 14.4 : C.A. 15.49) but lasts longer than average (1.55 years : 1.10

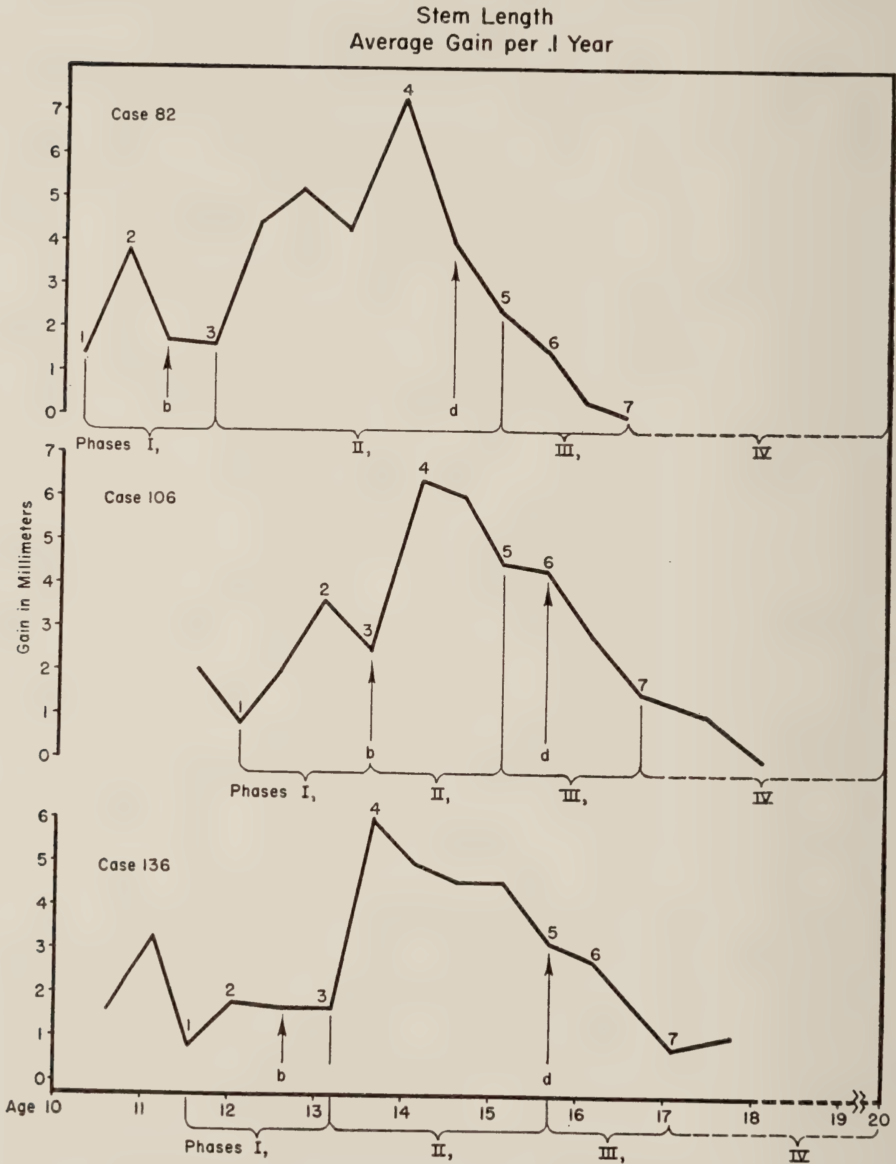


FIGURE 185c. These three profiles of stem length are examples of the 14.18 per cent of the cases in which the exact point of transition from one phase to the next is not clear-cut but the general pattern configuration is easily recognized (Cases 82, 106, and 136). These profiles suggest a tendency toward the elision of Phase II and Phase III which makes it difficult to be sure of the location of Point 5. The puberal period for *height* occurred between *b* and *d*.

years). For Phase IV this case supplies data for the first 1.5 years, the profile being very similar to the schematic profile for the group.

In Chapter VI we have drawn attention to our finding that obvious and often striking variation in growth velocity is characteristic for leg length profiles as compared to stem length profiles. This is illustrated by Case 120 whose individual growth curves we have just discussed. (See Figure 184.) This tendency toward configuration irregularity makes it more difficult to recognize the phase pattern, but of the 38 cases in which the data were adequate, 33 (86.95 per cent) show Phases I, II, and III unmistakably and also the early part of Phase IV. In five cases the phase pattern is recognizable, but the exact position of the flexion point between two of the four phases is not certain. In Figure 186a are shown three examples of clear-cut pattern, and in Figure 186b two of the less definite patterns.

THE PATTERN IN BIACROMIAL WIDTH GROWTH

The recognition of the phase pattern in the growth profiles for biacromial width is more difficult than for any of our other profiles. The biacromial profile of Case 120 shown in Figure 184 will serve to illustrate some of the reasons for this difficulty.

It will be noted that the specimen displays a number of discrepancies with the schematic profile for biacromial width shown in Figure 183. The latter part of Phase II, all of Phase III, and the early part of Phase IV approximate the schematic phase configuration, but in Case 120 Phase I commences .56 year earlier and lasts .55 year longer. Phase II begins at the group average (C.A. 12.91 years), but instead of accelerating without interruption to the puberal apex at Point 4, as in the schematic profile, it rises and falls at relatively low-level velocity for a year, then starts a rapid six month rise to an apex rate of almost twice the group average, and then shows an equally rapid six month fall. This tendency toward almost explosive increases in growth rate for relatively short periods separated by relatively long periods of low-level growth is characteristic of our biacromial width profiles. It renders more difficult the certain determination of Points 1, 3, 5, and 7.[4]

Of the thirty cases in which our data extended to cover Phases I, II, III, and part of IV, we could recognize the phase pattern in 22 (73.33 per cent); in 4 cases (13.33 per cent) the pattern was definitely suggested although not complete; in 4 cases (13.33 per cent) the location of the flexion points was too uncertain to justify the assumption that the pattern existed. In Figure 187, page 406, we give three profiles of growth in biacromial width which show a variety of recognizable phase patterns.

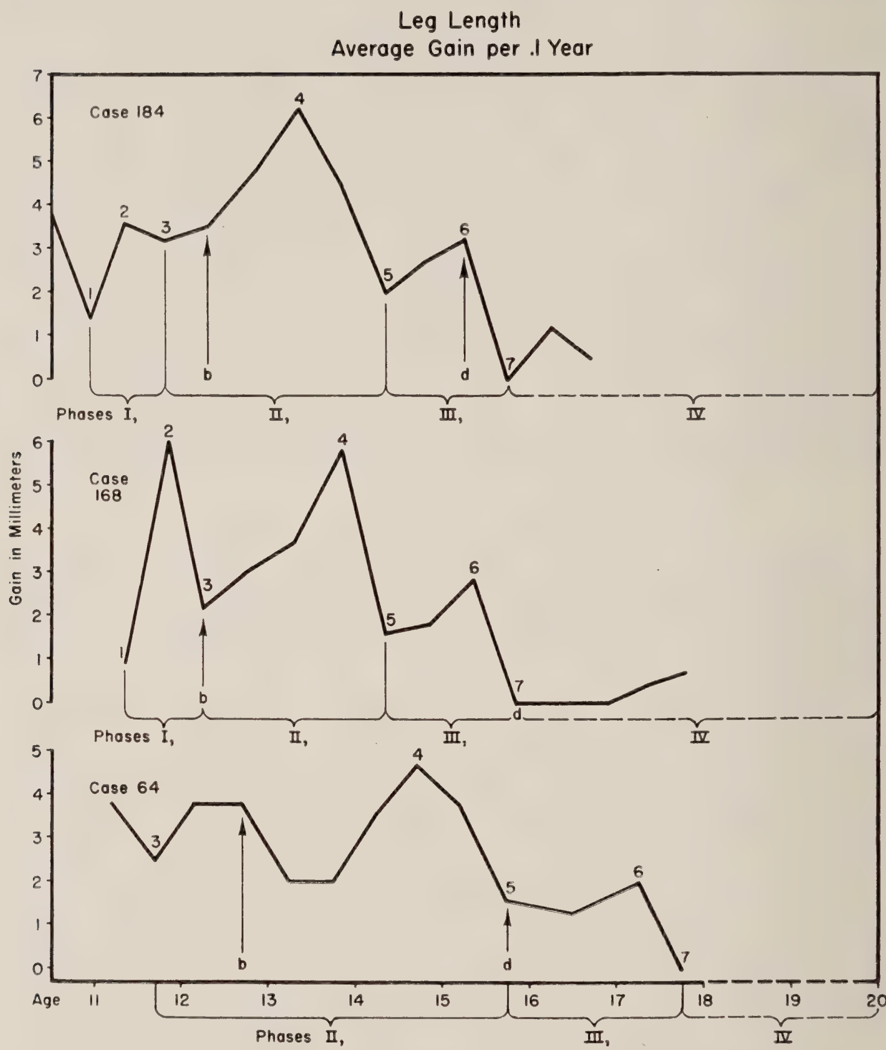


FIGURE 186a. These three profiles illustrate the three phase configuration pattern for leg length growth during adolescence. This pattern could be recognized in 86.95 per cent of the 38 cases studied. (*b* and *d* define the puberal period for height.)

THE PATTERN IN BI-ILIAC WIDTH GROWTH

The bi-iliac width growth profile for Case 120, with phases indicated, is shown in Figure 184. This specimen shows strong similarity to the schematic profile for bi-iliac width in Figure 183. On first inspection the location of Point 3 seems doubtful, but study of other profiles for the same case indicates that the low velocity fluctuation between C.A. 12.35 years and C.A. 13.45 years probably belongs in Phase II as we have shown it.

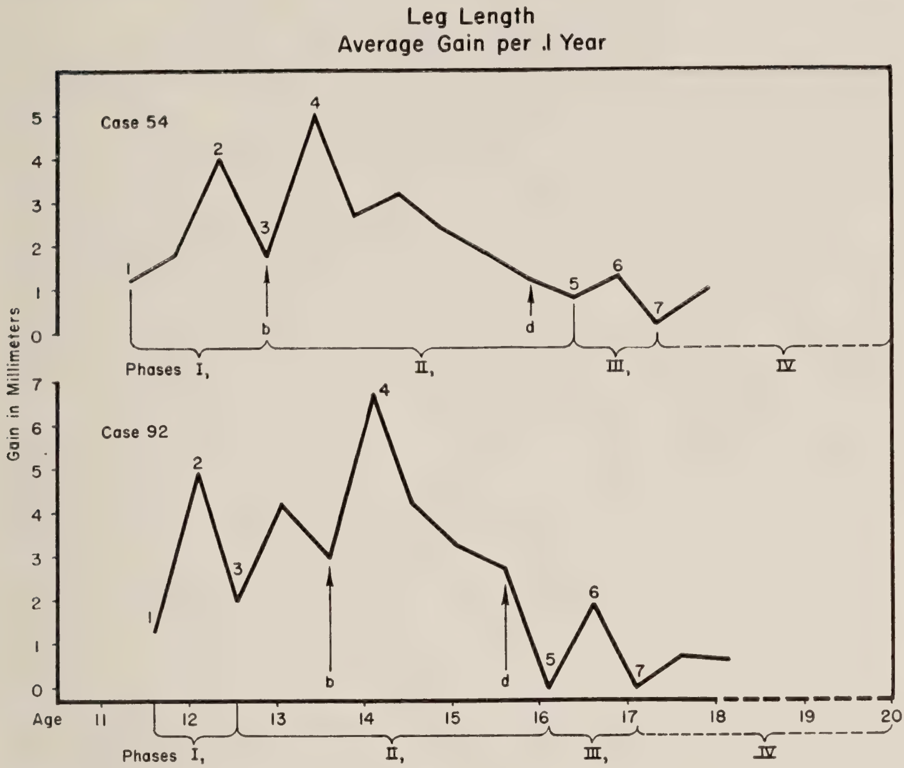


FIGURE 186b. The two profiles of leg length growth represent the 13.05 per cent of the sample studied which strongly suggest the three phase pattern but in which it is not possible to determine with certainty the exact location of the flexion which separates two of the phases.

Of 50 bi-iliac width profiles analyzed, 38 (76.00 per cent) show Phases I, II, and III complete and the early part of Phase IV. In the remaining 12 profiles (24.00 per cent) the three phase pattern is strongly suggested, but the exact location of one or more flexion points is not certain.

In Figure 188, page 407, we present five bi-iliac width profiles as examples of individual variations of the common basic pattern.

THE PATTERN IN WEIGHT GROWTH

Having found in our height growth profiles that the four phase sequence was discernible in only 11 of 54 cases, we were surprised to discover that it stood out in the weight growth more frequently and more obviously than in any of our other profiles. In Figure 189 we use Case 120 again as our specimen.

The individual configurations for weight growth vary widely, but in every case the puberal phase (Phase II) can be recognized as a period

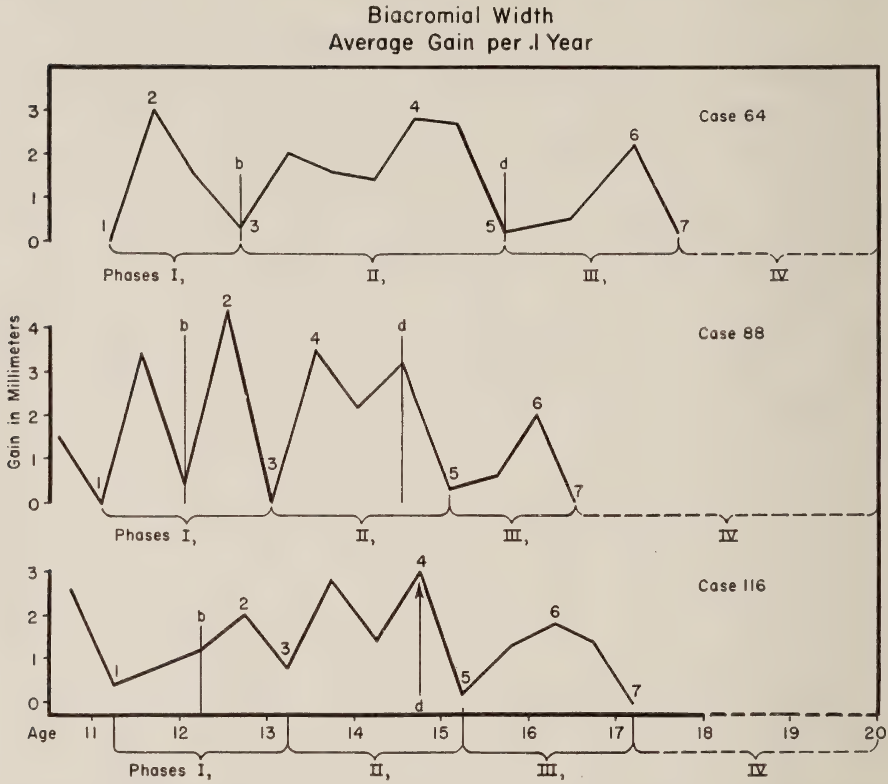


FIGURE 187. These three profiles of biacromial growth during adolescence illustrate individual differences in the configuration of the common four phase pattern. Case 88 shows an unusually marked interruption of Phase I growth.

of high velocity increase which is uninterrupted by any loss in weight, persists longer than any other period of relatively high growth velocity, and usually (46 out of 54 cases) includes the apex for velocity during the entire adolescent period.

The prepuberal phase (Phase I) includes one or more periods of increased growth velocity, varying in magnitude but of relatively short duration. These peaks may alternate with short periods of no gain or even of loss in weight.

The postpuberal phase (Phase III) is also characterized by short-duration changes in velocity which vary considerably in magnitude and may include periods of actual loss in weight.

As will be seen in Figures 190a, b, c, and d, the recognition of these three phases in the growth velocity profiles for weight is facilitated by reference to points b and d which indicate the onset and end of the maximum growth period for height. (See pages 410 and 411.)

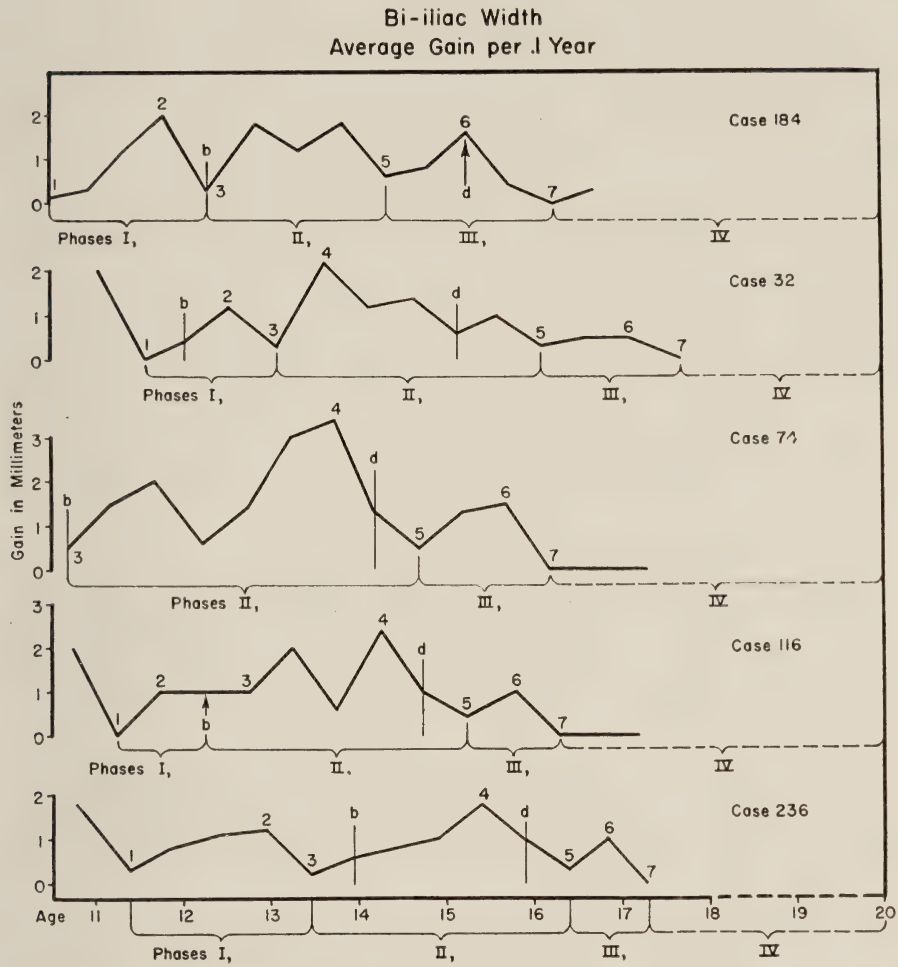


FIGURE 188. These five profiles of bi-iliac width growth during adolescence illustrate the individual differences which occur in the common four phase pattern. It will be noted that in all but one of these the puberal peak (Point 4) was the apex of adolescent growth velocity. In case 184 the prepuberal peak (Point 2) was the apex. Cases 32 and 74 were very tall boys; Case 116 was one of the shortest. Case 236 went through a long prepuberal fat period and his Phase I is .76 year longer than the average for the group.

The data for completely plotting Phase IV in weight growing are lacking. So far as they go, our weighings seem to indicate that for many of our boys there was a definite increase in adipose tissue starting in Phase III and continuing into the early part of Phase IV. This resulted in continued weight gain during late adolescence. However, we found no difficulty in distinguishing Phase III from Phase IV.

Of the 54 weight growth profiles which include adequate data for deter-

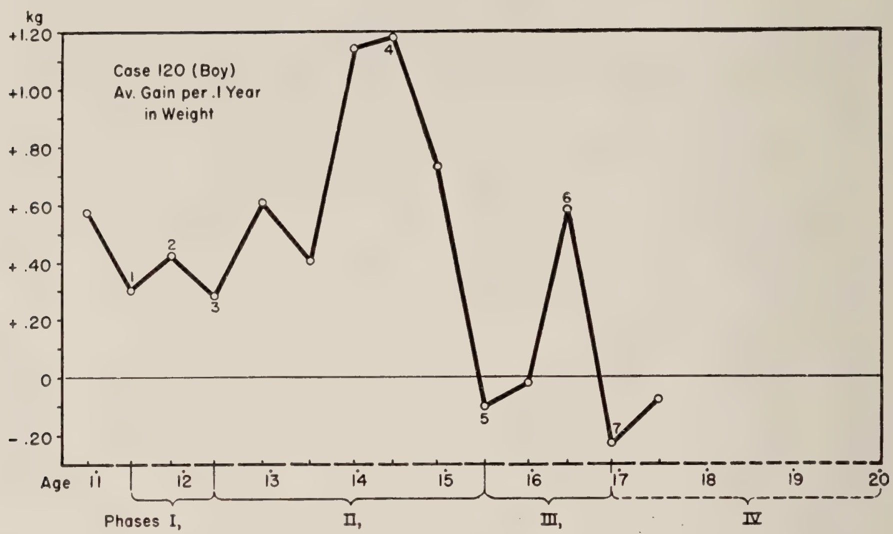


FIGURE 189. Weight growth profile for Case 120. As might be expected, the general configuration resembles that for height in certain respects. Unlike the usual height profile, however, it falls readily into the four phase pattern as indicated on the chart. Point 3 is the only flexion point about which there is room for doubt. In selecting the location we were influenced by the position of Point 3 in the other profiles for the same boy.

mining the seven flexion points, Phases I, II, and III could be recognized in all but one case (98.15 per cent). Thus, during the adolescent growth period the weight profile may be of great assistance in the appraisal of an individual's stage of maturity.

THE PATTERN IN MUSCULAR STRENGTH GROWTH

The patterned profile of the changes in muscular strength which Case 120 displayed during the first three phases of adolescent development are shown in Figure 191, page 412.

Our data are less convincing than for the other growth measures because the corresponding phases for strength occur so much later than for the others that in many cases Phase III was incomplete, and in all but nine cases Phase IV was entirely beyond the range of the seven year study. This was particularly unfortunate, since what data we had indicated that a large part of the adolescent increase in strength occurred during its last two phases. However, the strength profiles supply excellent examples of the low growth velocity period which separates childhood from Phase I of adolescence. Even lacking Phase IV they give considerable support to the phase pattern hypothesis. In Figures 192a, b, c, d, pages 414 and 415, we show four profiles of muscular strength increase divided into Phases I, II, and III.

A clear pattern for Phases I, II, and the first part of Phase III was easily discernible by inspection of the muscular strength profiles for 48 of the 66 cases. In 15 cases the three phase pattern was strongly suggested by the configuration, although the exact point of division between two of the three phases was less clear cut. Thus we may say that in 63 cases (95.4 per cent) this pattern was characteristic; in 3 cases (4.6 per cent) no tendency to follow the three phase pattern could be seen in the profiles.

TIMING RELATIONS OF PHASE PATTERNS

Interrelations for stem length, leg length, shoulder width, and hip width. From the schematic profiles based on mean values for the sample shown in Figure 183 on page 396, it is evident that the corresponding flexion points and phases for these four measures were not synchronous. The average C.A. values at the four flexion points which separate the phases were:

	Point 1	*Point 3*	*Point 5*	*Point 7*
Stem length	11.75	13.05	16.03	17.60
Leg length	11.45	12.50	15.49	16.59
Biacromial width	11.46	12.91	15.84	17.29
Bi-iliac width	11.64	12.93	15.66	17.03

The average durations in years of the first three phases were:

	Phase I	*Phase II*	*Phase III*	*Total*
Stem length	1.30	2.98	1.57	5.85
Leg length	1.05	2.99	1.10	5.14
Biacromial width	1.45	2.93	1.45	5.83
Bi-iliac width	1.29	2.73	1.37	5.39

These timing relations are shown in graphic form in Figure 193, page 416.

It will be noted that, on the average, leg length and shoulder width were the first to start the adolescent pattern, and stem length was the last; leg length finished the third phase a year before stem length; the duration of Phase II was almost the same for stem length, leg length, and shoulder width, while that for hip width was about three months shorter; the combined duration of Phases I, II, and III was longest for stem length and shoulder width and shortest for leg length.

RELATION OF PHASE POINTS TO THE ONSET AND END OF THE PUBERAL GROWTH PERIOD FOR HEIGHT

The usefulness as well as the probable validity of the phase pattern hypothesis which we have advanced in this chapter depends partly upon its consistency with other phenomena of somatic growth which have been more certainly established. To this end we have analyzed the timing of the phase pattern points in relation to the onset (b) and end (d) of the puberal

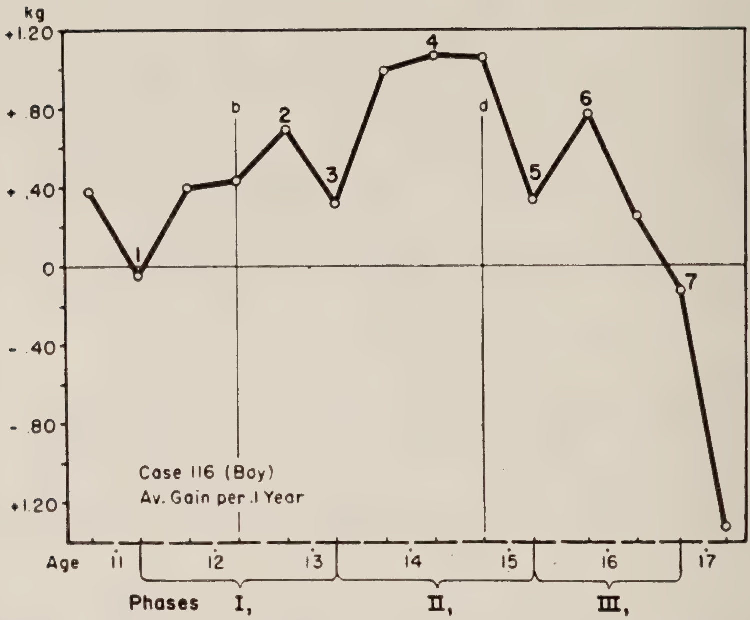


FIGURE 190a. This profile of growth velocity in weight during adolescence (Case 116) shows the Phases I, II, and III in most symmetrical form and without any flexions except those that define the pattern. Note the short period of slight loss just preceding the prepuberal phase and the period of definite loss which follows the post-puberal phase. In this case the puberal phase for weight commenced 1.0 year after the onset of the puberal period for height (b) and ended .5 year after the close of that period (d).

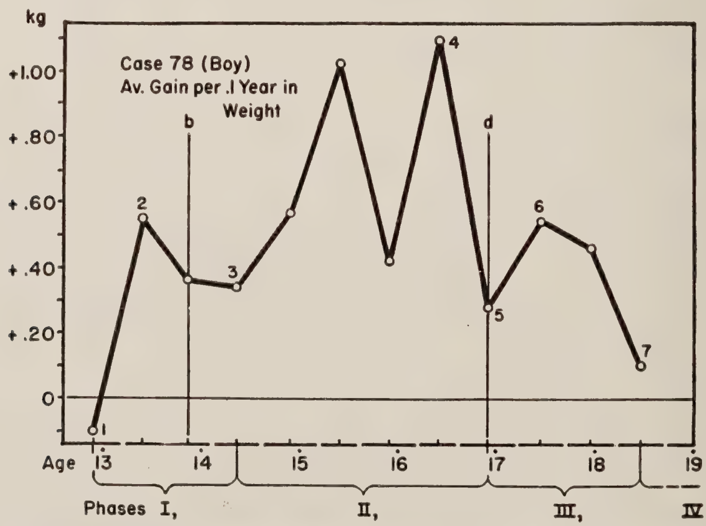


FIGURE 190b. In this profile of Case 78 the first three phases of the pattern for weight growth are plainly evident, despite the marked loss of growth momentum which occurred about the middle of the puberal phase. There was an actual loss in weight just prior to the prepuberal phase. Note the relation of the puberal phase to the puberal period for height (b to d).

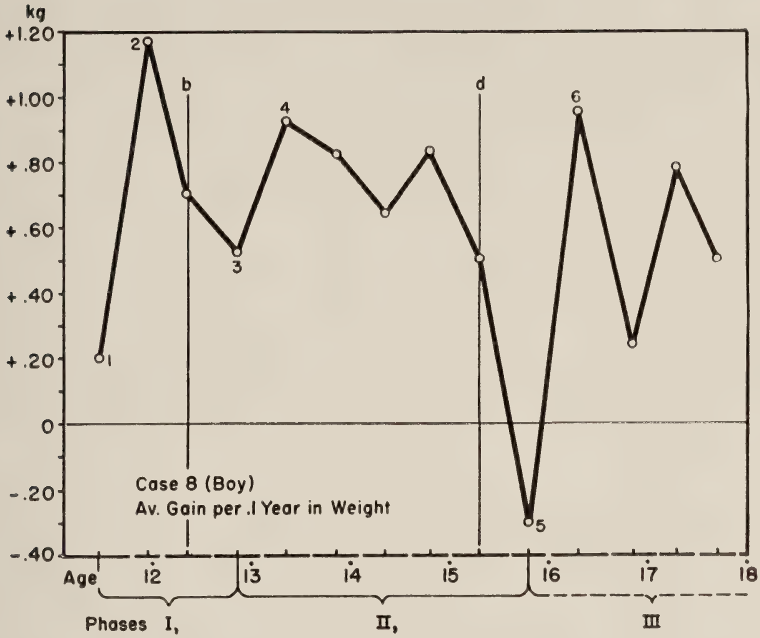


FIGURE 190c. This profile represents a boy (Case 8) of average stature whose bones and muscles grew with unusual rapidity during adolescence. He carried no excess fat. Note the apex for weight growth occurring in the prepuberal phase and also the high velocity level at which the puberal phase commenced. During .4 year following the puberal phase he lost about ten pounds, but immediately thereafter, during the postpuberal phase, resumed his high rate of gain.

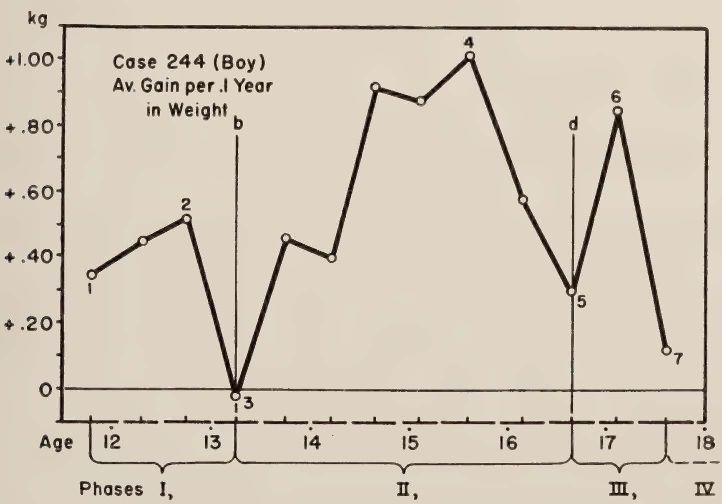


FIGURE 190d. This profile of weight growth (Case 244) shows a moderate increase in rate during the prepuberal phase, a short period of no gain, a long puberal period of high growth velocity, and a final spurt of high intensity but short duration in the postpuberal phase.

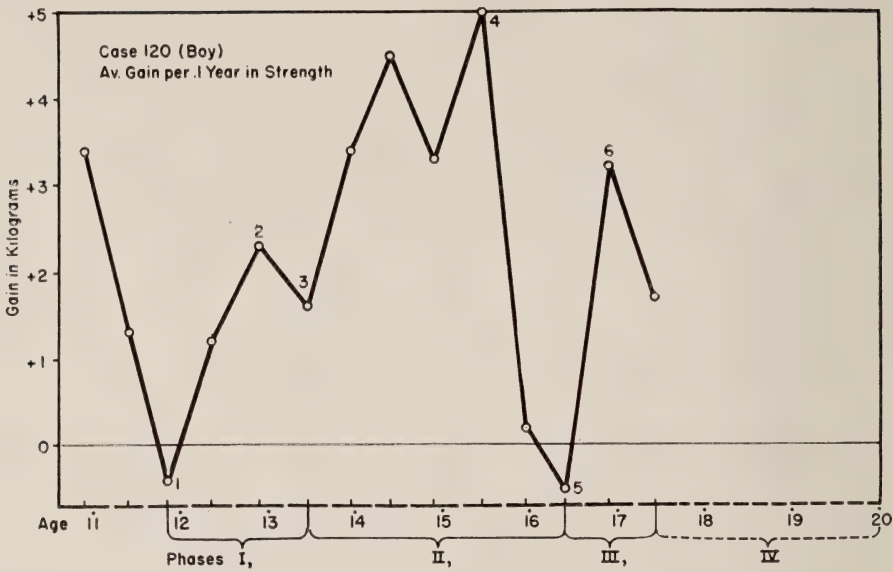


FIGURE 191. Profile of strength changes for Case 120 during Phases I, II, and III. Our data did not include any part of Phase IV because increase in strength lagged a year or more after the other growth phenomena. This profile shows the separation of the childhood phase from the prepuberal phase with unusual decisiveness (Point 1). Note the marked postpuberal increase in strength; this was characteristic for the majority of our cases. In 95.4 per cent of the 66 cases studied, the first three phases of the four phase pattern were clearly outlined or strongly suggested.

growth period for height as described in Chapter IV. Specifically, we first determined for each case the chronological ages at which Point 1 for stem length, Point 1 for leg length, Point 1 for shoulder width, and Point 1 for hip width occurred. We noted the duration of the period which included all four. For convenience of reference we called the period the *Point 1 Zone.*

We then found whether the onset of the puberal period for height occurred before, during, or after the Point 1 Zone. When b occurred outside the zone, we noted how long before or how long after it fell.

The same process was repeated for Point 3. For Points 5 and 7 the same thing was done, except that the comparison was made with the end of the puberal period for height (d).[5]

Some of the data thus secured are summarized in Table 109. From these it is clear that the onset of the puberal period for height (b) did not ever come before the beginning of Point 1 Zone, which means that it did not ever come in the childhood period before Phase I for any of the four measures. In one case it occurred during the Point 1 Zone. In 86 per cent of the cases it came from .5 year to 1.5 years after Point 1 Zone.

The onset of the puberal period for height (b) fell within the Point 3 Zone in 58 (91 per cent) of the cases, and the other 6 cases all fell within .5 year of the zone margins.

The end of the puberal period for height (d) fell in the Point 5 Zone in 61 (95 per cent) of the cases, and the other 3 cases all fell within .5 year of the zone margins.

The end of the puberal period for height (d) fell before the Point 7 Zone in 34 cases (94 per cent) and within that zone in 2 cases. This relation varied somewhat more widely than the other three, but in 78 per cent of the cases it fell from .5 year to 1.5 years before Point 7 occurred for any one of the four measures.

Table 109 RELATION OF b AND d FOR HEIGHT TO THE ZONES FOR POINTS 1, 3, 5, AND 7 OF THE PHASE PATTERNS FOR STEM LENGTH, LEG LENGTH, BIACROMIAL WIDTH, AND BI-ILIAC WIDTH

Height Profile Points	*Phase Point Zones*											
	Point 1			Point 3			Point 5			Point 7		
	Before	In	After	Before	In	After	Before	In	After	Before	In	After
b	0	1	28	2	58	4						
d							1	61	2	34	2	0
Number of cases	29			64			64			36		

RELATION OF PHASE POINTS TO DEVELOPMENTAL POINTS FOR TESTES GROWTH AND GLANS PENIS GROWTH

In Chapter XIV we presented data establishing recognizable periods of rapid growth for the testes and for the glans penis which commenced at Points T_1 and P_1 and ended at Points P_2 and T_2. The timing relations of the phase pattern points to these developmental points for male genitalia were analyzed case by case in much the same way we used for height, and a similar summary is shown in Table 110, page 416.

From this table it appears that the relation between the genital developmental points and the phase point zones is less definite than that of Points b and d for height. However, when we analyzed the location of the T_1 in the 13 cases in which it fell outside the Point 1 Zone, we found that in 10 of them T_1 fell within .25 year of the zone. Thus, there were 26 cases (88 per cent) in which the onset of the accelerated growth period for testes occurred between .25 year before and .25 year after the Point 1 Zone.

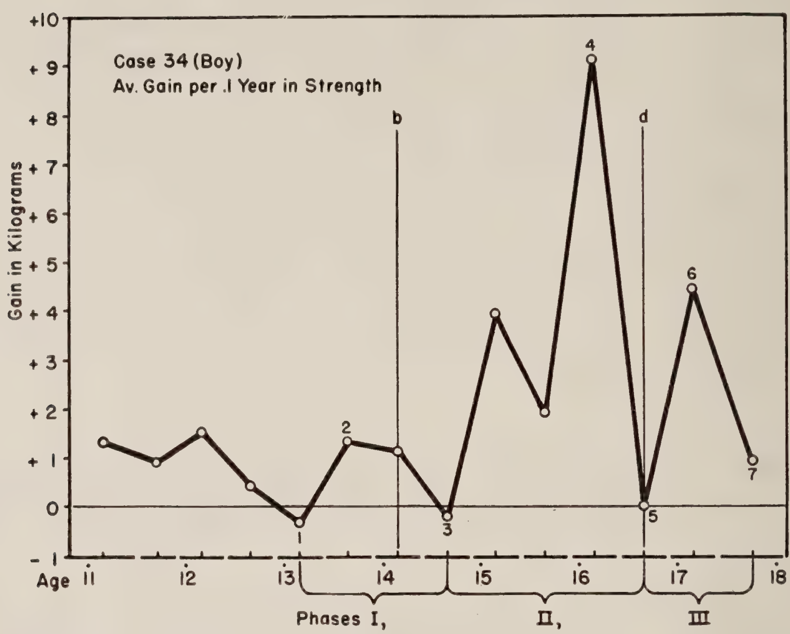


FIGURE 192a.

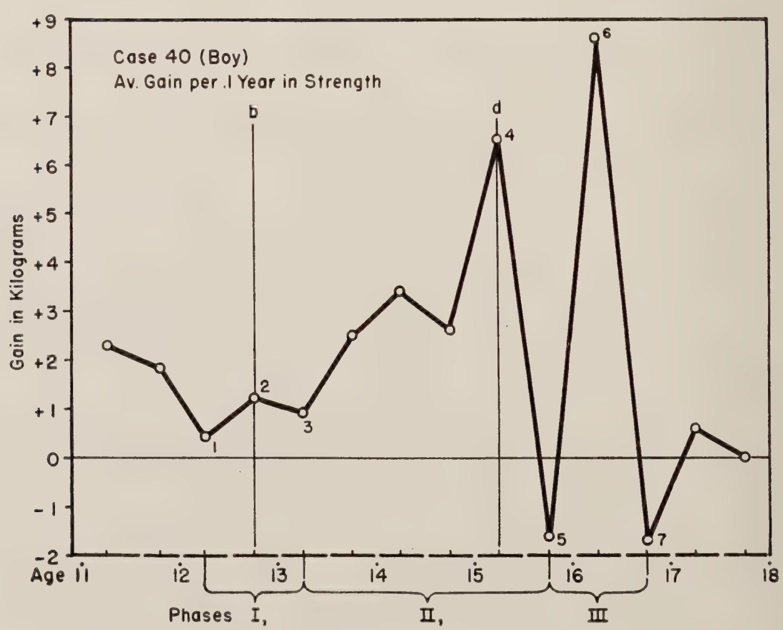


FIGURE 192b.

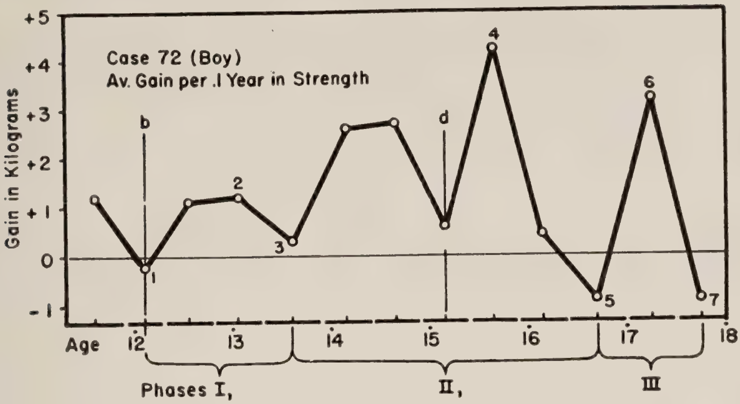


FIGURE 192c.

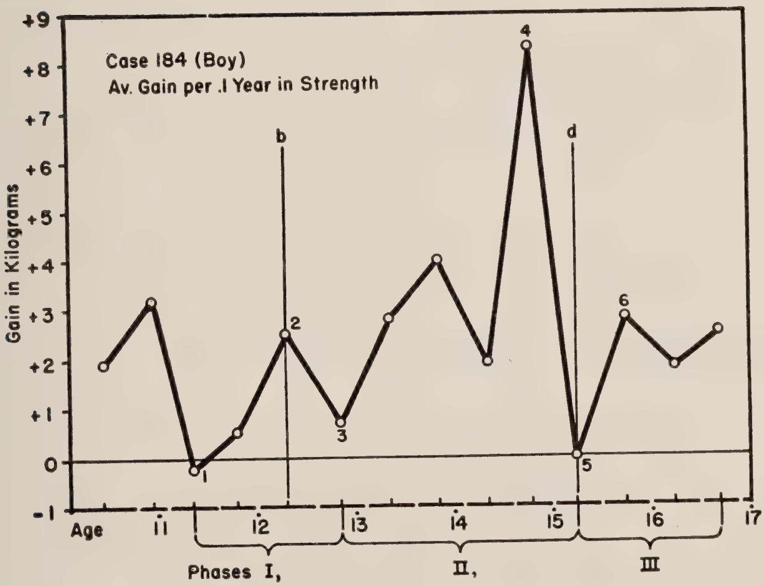


FIGURE 192d.

FIGURES 192a, b, c, and d. These profiles of strength gain show the first three phases of the common adolescent phase pattern in a variety of individual configurations. Note that Case 34 was somewhat retarded in adolescent skeletal growth but relatively less retarded in development of muscular strength. Case 40 exhibited his highest rate of strength increase during the postpuberal phase. (Phase III.) Case 72 was a tall, asthenic boy whose rate of strength increase was among the lowest in the group. Case 184 was a boy of average height, and his rate of strength gain was close to the mean for the group. For him Phase III for strength lasted longer than usual, ending (presumably) at about C.A. 17.25 years.

Table 110 RELATION OF POINTS T_1, T_2 FOR TESTES GROWTH AND POINTS P_1, P_2 FOR GLANS PENIS GROWTH TO ZONES FOR POINTS 1, 3, 5, AND 7 OF THE PHASE PATTERNS FOR STEM LENGTH, LEG LENGTH, BIACROMIAL WIDTH, AND BI-ILIAC WIDTH

	Phase Point Zones											
Genital Growth Points	Point 1			Point 3			Point 5			Point 7		
	Before	In	After	Before	In	After	Before	In	After	Before	In	After
T_1	3	16	10									
P_1				12	43	9						
P_2							46	18	0			
T_2										24	12	0
Number of cases	29			64			64			36		

The onset of the accelerated growth period for glans penis (P_1) came during the Point 3 Zone in 67 per cent of the 64 cases, and only for 2 cases (3 per cent) did P_1 fall outside the zone by more than .25 year.

The end of the rapid glans penis growth period (P_2) occurred either before or in the Point 5 Zone. For 61 cases (95 per cent) it fell between .75 year before the zone and the end of the zone.

The end of the rapid growth period for testes (T_2) bore a similar timing relation to the Point 7 Zone, with 34 cases (97 per cent) in which T_2 fell between .75 year before the zone and the end of the zone.

From these analyses of the timing relations between the phase pattern points and developmental points for height and genitalia, we conclude that

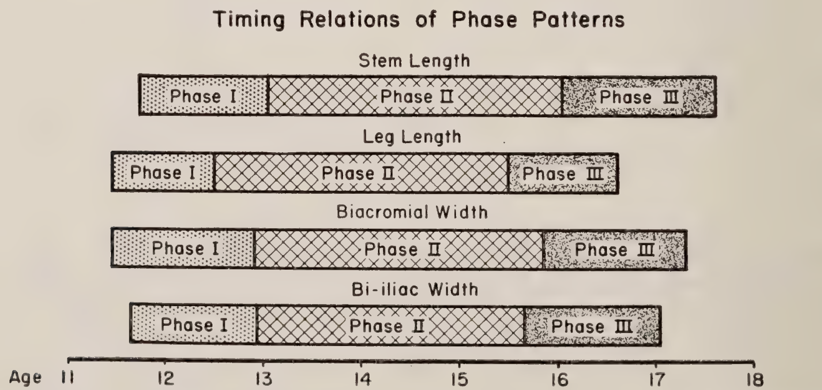


FIGURE 193. In this figure the average timing relations of the first three phases of the adolescent phase patterns for stem length, leg length, shoulder width, and hip width are represented for our sample of boys.

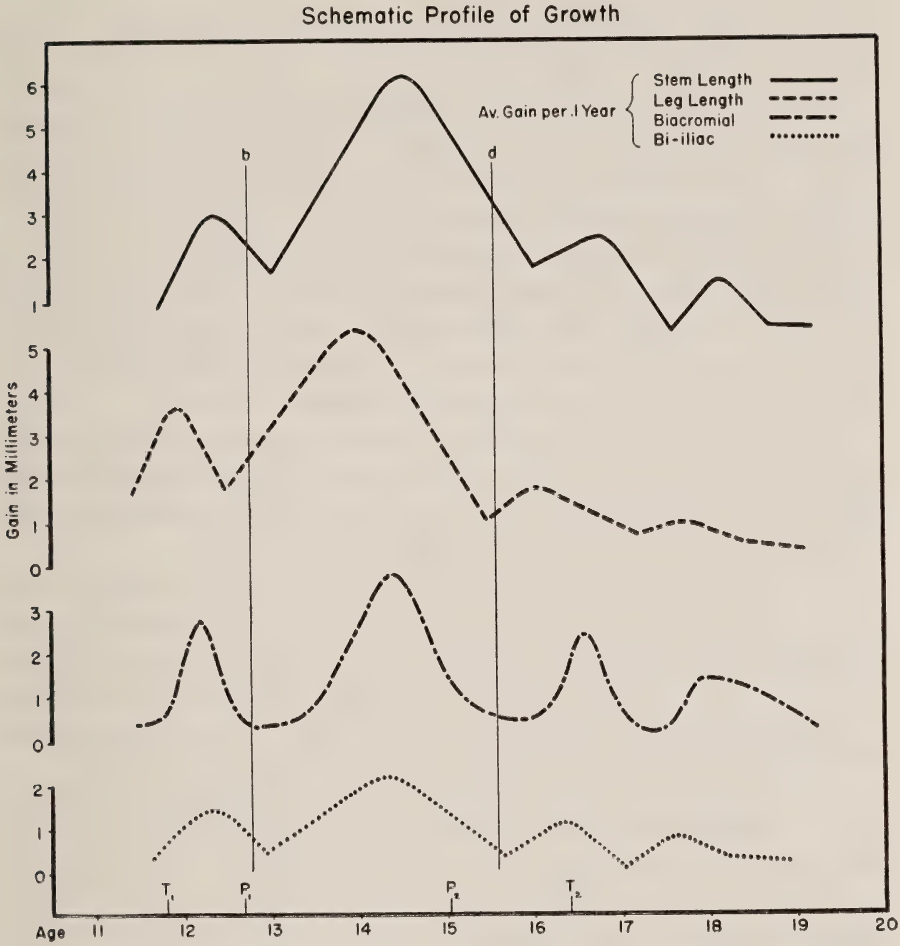


FIGURE 194. These are the same schematic phase pattern profiles for the stem length, leg length, biacromial width, and bi-iliac width which are shown in Figure 183 on page 396. The timing relations to the puberal period for height are indicated by the letters b and d. The timing relations to puberal growth in testes and to puberal growth in glans penis are indicated by T_1 and T_2, P_1 and P_2. The validity of the phase pattern hypothesis is strengthened by the consistency with which specific points along the several growth profiles tend to show a constant timing relation to stigmata of progress in other aspects of development.

the use of phase sequence analysis in conjunction with other stigmata of maturation yields a significant increase in accuracy of appraisal of progress toward maturity.

The chart in Figure 194 presents the profiles shown in Figure 183, and the group mean positions of Points b and d for height, and T_1, P_1, P_2, and T_2 for genitalia.

SEASONAL VARIATION IN GROWTH RATE IN RELATION TO THE PHASE PATTERN

Since from the work of other investigators the hypothesis is generally accepted that the rate of growth in height varies during each year in relation to seasonal factors, it is important to determine to what degree the adolescent rhythm of growth may be the result of such factors.

The method of data collection used with our sample makes this analysis difficult. The boys were measured twice a year at intervals which closely approximated .5 year.[6] But while some boys were measured in September and February, others were measured in December and May. In every month except July there were some examinations scheduled.

Factors of temperature, sunlight, moisture, and food variety are less closely related to given months and seasons in the San Francisco Bay area than in most continental areas. Only rainfall follows a fairly constant pattern of significant seasonal variation.

In view of these circumstances we have made no attempt to parcel out the seasonal factors. We have, however, analyzed and arranged our data to find out whether or not the periods of low velocity growth which separate Phases I, II, III, and IV of the adolescent phase pattern are predominantly coincident with summer or winter growth. Our findings are summarized in Tables 111, 112, and 113.

In Table 111 we have compared the timing of flexion points 1, 3, 5, and 7 of the phase pattern. If any two points occurred 1, 2, 3, 4, or 5 years apart, we have counted them as occurring at a corresponding season; if they occurred 1.5, 2.5, 3.5, or 4.5 years apart, they were not so counted. For this analysis we have used only profiles which include all four of the flexion points.

Table 111 SEASONAL TIMING CORRESPONDENCE OF PHASE PATTERN POINTS

(Based on 42 Boys for Stem Length; 29 Boys for Leg Length)

Points	*Occurrence at Corresponding Season*			
	Stem Length Profile Cases		Leg Length Profile Cases	
	Number	Per Cent	Number	Per Cent
1 and 3	28	66.7	16	55.2
1 and 5	18	42.8	13	44.8
1 and 7	18	42.8	12	41.4
3 and 5	24	57.1	18	62.1
3 and 7	18	42.8	9	30.4
5 and 7	18	42.8	12	41.4

For the group only Points 1 and 3 for stem length and 3 and 5 for leg length show any significant tendency toward occurrence at the same time of year. Points 3 and 7 for leg length show a definite tendency to occur at different times of year. All of the other comparisons indicate that seasonal rhythm of growth does not play a significant part in determining when the adolescent phases begin and end.

In Table 112 we summarize for 42 stem length and 29 leg length profiles our findings as to the consistency with which Points 3, 5, and 7 occur at the same time of year as Point 1. It will be noted that both for stem length and for leg length every one of the eight possible patterns is represented. No one pattern includes as many as 25 per cent of the cases. All four points occurred at the same time of year for only 11.9 per cent in stem length and 6.9 per cent in leg length. In 47.6 per cent of the 42 stem length profiles, three of the four points occurred at corresponding times of year; this occurred in 48.2 per cent of the 29 leg length profiles. For stem length two points corresponded and two did not in 40.5 per cent; in leg length in 44.8 per cent.

Table 112 CONSISTENCY PATTERNS OF SEASONAL OCCURRENCE OF PHASE POINTS 1, 3, 5, AND 7

(S Means Same Season as Point 1; O Means Opposite Season from Point 1)

Point 3	*Point 5*	*Point 7*	*Stem Length*		*Leg Length*	
			Number	Per Cent	Number	Per Cent
S	S	S	5	11.9	2	6.9
S	S	O	9	21.4	7	24.1
S	O	S	6	14.3	2	6.9
O	S	S	1	2.4	2	6.9
O	O	O	4	9.5	3	10.3
S	O	O	8	19.0	5	17.2
O	S	O	3	7.1	2	6.9
O	O	S	6	14.3	6	20.7
	Total		42	99.9	29	99.9

In Table 113 we summarize our comparison of the frequency with which low velocity growth at Points 1, 3, 5, and 7 for stem length and leg length phase patterns occurs during Period A which *did not* include any summer months (June, July, August) as against Period B which did include these months. In view of the summer, Christmas, and Easter school vacations this division seemed the most promising for bringing out any relation of environmental factors to the adolescent growth rhythm. From the table it will be seen that for stem length growth there was a definite tendency for Points 1, 3, and 5 to occur more frequently during Period B which in-

cluded the summer months. However, even these three points occurred in Period A in more than a third of our cases, and Point 7 fell in Period A in almost two thirds (64.4 per cent) of the cases. For leg length growth Points 1 and 3 showed a definite tendency to occur during Period B, but more than one third of the cases fell in Period A; Points 5 and 7 were almost equally divided between the two periods.

Table 113 RELATION OF LOW VELOCITY GROWTH POINTS IN THE PHASE PATTERN TO SUMMER GROWTH

(Period A Includes *No* Summer Growth; Period B Includes Summer Growth)

Point	*Occurrence in Period A or Period B*									
	Stem Length					Leg Length				
	Number of Cases	Period A Number	Period A Per Cent	Period B Number	Period B Per Cent	Number of Cases	Period A Number	Period A Per Cent	Period B Number	Period B Per Cent
1	57	20	35.1	37	64.9	31	12	38.7	19	61.3
3	56	24	42.8	32	57.2	31	15	48.4	16	51.6
5	51	20	39.2	31	60.8	31	11	35.5	20	64.5
7	45	29	64.4	16	35.6	27	14	51.9	13	48.1

SUMMARY AND CONCLUSIONS

As the graphic profiles of velocity changes in skeletal growth for our 67 boys were extended through the years of adolescence, they manifested, in many cases, the same general pattern of cyclic phases. In this chapter we have presented data to support the hypothesis that between childhood and the completion of skeletal growth there are usually four recognizable phases: Phase I, or prepuberal phase; Phase II, or puberal phase; Phase III, or postpuberal phase; and Phase IV, or late adolescent phase.

We have discussed in detail for stem length, leg length, shoulder width, and hip width the incidence, configuration, and seasonal relations of the first three phases and have presented a few data concerning Phase IV. We have also applied the hypothesis to the profiles of weight change and muscular strength change during adolescence. The timing relations of corresponding phases for the several measures have been analyzed, and also the timing relations between the phase pattern flexion points and specified developmental points for height and for the genital organs.

In at least 75 per cent of all profiles of boys' growth velocity in stem length, leg length, shoulder width, hip width, weight, and muscular strength during adolescence, there was a common rhythmic pattern.

For any given boy this pattern was individualized in the sense that it showed unique configurational characteristics. There was also a definite tendency toward pattern similarity among all profiles of the same growth measure, e.g., leg length, or weight.

The basic rhythmic pattern consisted of three acceleration-deceleration phases, and was followed by a fourth phase of intermittent low velocity growth.

The initial characteristic of the pattern was a period of low velocity growth for .5 year, which separated childhood from adolescence.

The corresponding flexion points in the individual's phase patterns for stem length, leg length, shoulder width, and hip width occurred within a time span of from .5 year to 2.0 years.

Phase II of the pattern (the puberal phase) lasted much longer than either Phase I or Phase III and usually included the period of maximum growth velocity during adolescence.

In timing, each of the several phases for each of the several measures showed a strong tendency toward systematic relation to the onset and the end of the puberal period for height growth and for genital growth.

The duration of the several phases in each individual boy's edition of the basic pattern was determined *primarily* by growth forces inherent in that individual when he entered adolescence rather than by seasonal or other environmental factors operating during his adolescence.

We are aware that the profiles we used for our analyses were too few and too limited in time range, and were based upon examinations too widely spaced to support more than tentative conclusions. We present such conclusions in the hope that they may stimulate other investigators to test the adolescent phase pattern hypothesis, and because even in their present form they can be useful in the more definite appraisal of the somatic maturity of an individual boy.

FOOTNOTES FOR CHAPTER XVI

1 Specifically, some of the shortcomings of the schematic curves are as follows: the range of timing and growth velocity values, of which Points 1, 2, 3, 4, 5, 6, and 7 represent the mean, is wide; for each measurement there were profiles which could not be fitted into the four phase schema; the number of cases for which the data permitted the determination of all seven points was very limited. Data indicating more exactly these shortcomings will be found in the discussion of the application of the phase hypothesis to each of the growth measures.

2 For an explanation of the causes of such fluctuations, see the discussion of the contours of the biacromial growth curve in Chapter VII, pages 175–177.

3 Point 6 is actually lower than Point 5. Why, then, was this called a phase rather than a minor deflection? Because inspection of the profiles of this case for leg length, biacromial width, bi-iliac width, weight, and muscular strength all show a clear Phase III corresponding in profile relations to such a Phase III for stem length. This can be readily seen by comparing the four profiles in Figure 184.

4 For pertinent discussion of the profile configuration for biacromial width, see page 175 in Chapter VII.

[5] The numbers of cases analyzed, the mean duration, and the range of duration for each of the four zones were:

Zone	*Range*	*Mean*	*Number of Cases*
Point 1	.5–2.00 years	.99 years	29
Point 3	.5–2.00 years	1.36 years	64
Point 5	.5–2.00 years	.93 years	64
Point 7	.5–2.00 years	1.00 years	36

[6] See Appendix D for intervals between examinations.

Chapter XVII GENERAL SUMMARY AND DISCUSSION

THE specific findings of this study have been summarized at the end of each chapter, but, until the several aspects of growth had been dealt with separately and in detail, it was not possible to draw attention to the pervasive characteristics of the integrated process, or to discuss the implications which emerge from the related patterns of development. Indeed, the detailed presentation of the data as analyzed, and the step by step documentation which the novelty of these analyses demanded, may have tended to obscure the broader features of the on-going growth sequence through which these adolescent boys passed. In this chapter we will attempt to present in condensed form and without documentation certain generalizations which are based upon the data already presented and upon the related clinical observations that this investigation afforded.

ADOLESCENCE AS A DIFFERENTIATED STAGE OF DEVELOPMENT

The process of somatic growth through which human beings pass from conception to physical maturity is not one of steady increase in dimensions and mass. Upon the basis of changes in the rate pattern an individual's growth may be divided into four major stages: (1) the cycle of prenatality and infancy, (2) the plateau of childhood, (3) the puberal cycle, and (4) the low plateau of late adolescence.

Broadly speaking, the *period of adolescence* as commonly understood, includes the last two of these four major stages. For most boys, adolescence starts and ends within the second decade of life, but among individual boys there is a range of difference of at least five and a half years in the chronological age at which adolescence commences, and a difference range of at least four and a half years in the chronological age at which it ends. Thus, one boy may be entering adolescence at age ten years while he is in the high fifth grade, while for an age peer classmate childhood may continue until he is fifteen and a half years old and in the low eleventh grade.

THE GROWTH PATTERN DURING ADOLESCENCE

From this study of 67 boys whose growth in many aspects of development was recorded each six months over a period of seven years, it has

been found that, typically, adolescence consists of four distinct phases. These phases are defined by changes in the *rate* of growth. The tendency toward the four phase sequence pattern is apparent not only for each of the several skeletal measures but also for growth in weight and in muscular strength. Moreover, specific phenomena of sex-appropriate procreative ripening usually show coherent timing relations to these specific phases of the somatic growth pattern.

Phases I, II, and III are subdivisions of the puberal cycle; Phase IV is the low-level growth plateau of late adolescence. Each of the first three phases tends to take the form of a distinct acceleration-deceleration growth rhythm, with the peaks of Phases I and III flanking the central apex of Phase II.

Phase II is the puberal phase proper and lasts from two to four years; Phase I and Phase III are the prepuberal and postpuberal phases, respectively, and each lasts from one to two years. With but few exceptions Phase II lasts slightly more than twice as long as Phases I and III combined.

THE GROWTH PROFILE FOR HEIGHT AS A REFERENCE TIMETABLE

The corresponding phases of an individual's adolescent growth in height, stem length, leg length, shoulder width, hip width, thigh circumference, weight, strength, and the other measures show a strong tendency to occur *asynchronously*. For purposes of describing these differences in timing it is necessary to select developmental points on profiles of *one* aspect of growth as reference points. In this presentation we have used the onset, apex, and end of the puberal growth period for height as the primary points of reference because height is the largest and most commonly used dimensional measurement and because in growth profiles the puberal phase for height is easily recognized. It should be emphasized, however, that *there is no one aspect of development which can be taken as accurately representative of adolescent growth,* even for an individual. The profile of each of the several measures shows its own pattern peculiarities in timing and configuration. The height growth profile gives the necessary initial orientation, but an understanding of the process of change can be gained only through consideration of the relations among corresponding developmental points for several measured items. Some of the identifying characteristics of the four phase pattern are more easily seen in the profiles for leg length or stem length or weight or muscular strength than in those for height. The zone of transition from childhood to adolescence is frequently rather poorly defined in the height profiles but easily seen in some of the others.

This is due to the fact that height is a composite of the asynchronous growth of legs and trunk. Similarly, the zone of transition between the post-puberal and late adolescent periods often can be identified more readily by reference to the developmental points in other aspects of growth than from the configuration of the height profile alone.

We are convinced that the complex pattern of corresponding but asynchronous growth spurts so characteristic of the puberal cycle cannot be accurately charted in terms of any single aspect of that development, whether it be of hair or bones or genitalia or a skeletal measurement. However, the configurational flexions of the height growth profile may serve as useful reference points for describing the relations of other phenomena.

SOME GENERAL CHARACTERISTICS OF ADOLESCENT GROWTH IN BOYS

Using the height growth profiles as reference frames, several generalizations emerge relative to other growth phenomena during adolescence.

Growth in leg length. The onset of the prepuberal growth in leg length is one of the earliest signs that childhood has ended, and the cessation of significant increase in this measure indicates that late adolescence (Phase IV) will soon begin. Apex growth in leg length tends to occur either before or with apex growth in height. Following its apex, leg length growth rate decelerates rapidly during its puberal phase and rises but slightly during the postpuberal phase. Leg length growth during early adolescence (Phases I and II) is apt to vary widely in rate from one six month period to the next, and this with little or no relation to season. Six month periods without any increase are not uncommon prior to the puberal phase.

Growth in stem length. Low growth rate in stem length for six months or longer early in the prepuberal period for height is one of the most reliable indications that the puberal cycle has commenced. The dip in the stem length profile usually follows the corresponding dip for leg length. The puberal cycle for stem length growth usually extends for from six months to a year and a half after that for leg length. Apex rate in stem length growth tends to occur with or after apex for height. Growth in height during the latter part of the puberal period and during the postpuberal period is usually largely in the stem length component. The four phase pattern for stem length growth is easily recognizable because minor fluctuations are less frequent and less marked than in other profiles. In comparison to the leg length profile the peak of Phase I for stem length tends to be lower and the peak of Phase III higher.

Growth in shoulder width. The profiles for biacromial growth during adolescence show a wider range of individual pattern differences than those for any of the other skeletal measures. In many cases the prepuberal phase occurs as early as in leg length and the postpuberal as late as in stem length. The profiles tend to follow the phase pattern, but the main peaks rise more abruptly than in the curves for the other skeletal dimensions, with longer periods of low rate growth between main peaks. The postpuberal peak is often nearly as high as the puberal apex and there is a definite tendency for biacromial growth to continue during Phase IV at a relatively higher level than that shown by other dimensions. The maximum growth rate for shoulder breadth occurs with slightly greater frequency after the puberal apex for height than before.

Growth in hip width. The profiles for bi-iliac growth show a strong tendency to fall into the four phase pattern. The onset of the prepuberal phase usually occurs close to the onset for stem length, and the early prepuberal dip is often easily recognizable. Except in cases with marked early adolescent obesity, the bi-iliac apex usually occurs within the puberal period for height and not far distant from the height apex.

Changes in the stem length/height ratio. During the prepuberal period for height the ratio of stem length to standing height decreases. This decrease continues into the early part of the puberal period, but before the middle of the period the ratio tends to commence increasing as stem length replaces leg length as the dominant height growth component. This ratio increase persists into the early part of the postpuberal period, after which changes become slight, and there is no general trend.

Changes in biacromial/bi-iliac ratio. The average ratio of shoulder width to hip width increases significantly during adolescence, but the timing pattern of this increase does not show any general relation to the developmental phases of height growth until the latter part of the postpuberal period when many boys exhibit a rather abrupt gain which continues into the early years of late adolescence (Phase IV).

Changes in subcutaneous tissue thickness. For boys the process of development during adolescence includes as one of its phenomena a pattern of sequential changes in the thickness of the subcutaneous tissue layer. These sequential changes tend to show specific timing relations to the several phases of height growth. During the prepuberal period for height, increase in subcutaneous tissue is typical, although the amount of such increase varies widely. This early adolescent fat increase peaks at or near the onset of the puberal period for height and is followed by a decrease which extends to the end of that period. During the postpuberal period there is a second increase phase which sometimes levels off and sometimes continues

during the first years of late adolescence. This pattern of sequential changes may be broken by severe illness and may be somewhat modified by unusual nutritional conditions but occurs with surprising consistency among boys who vary widely in height, weight, body proportions, and other physical characteristics. It appears highly probable that the changes in subcutaneous storage of fat are but local manifestations of a generalized pattern of fat metabolism specifically geared to the process of normal somatic growth.

CHANGES IN THE COMPONENTS OF WEIGHT

As boys pass through adolescence their rate of gain in weight follows the four phase pattern with remarkable consistency, and with few exceptions the weight growth profiles show a systematic timing relation to the height growth profiles. In each of the four phases weight growth tends to lag behind height growth by six months or more. Exceptions are most apt to occur in those cases in which there is a marked storage of fatty tissue during the prepuberal and early puberal periods.

By comparative analysis of the profiles for the several skeletal measures, for subcutaneous tissue, for thigh circumference, and for weight, it is possible to deduce certain generalizations concerning the relative contributions of specified tissues to weight at successive stages of adolescent development. Changes in skeletal length and breadth represent changes in weight of bone, connective tissue, and muscular tissue, and also changes in all organs and tissues which support their metabolism. Changes in subcutaneous thickness represents changes in fat storage. Changes in thigh circumference are largely due to changes in muscular mass and sometimes in fatty tissue mass.

The growth profiles indicate that, in general, changes in adipose tissue play a relatively greater part in determining the configuration of the weight growth profile during the prepuberal period; that during the puberal period increase in weight tends to parallel closely increase in skeletal dimensions; that in the postpuberal period there is apt to be a close resemblance between the growth profiles for thigh circumference and for weight. In late adolescence tissue increase owing to skeletal growth becomes a relatively unimportant component; in the majority of boys increases in muscle mass continue to produce weight; in a minority the configuration of the Phase IV weight growth profile depends upon gain or loss in fatty tissue mass.

In those boys who throughout adolescence show little tendency to store fat, the weight growth profile tends to parallel the skeletal growth profiles in their general trends until late in the puberal period when cross-sectional increase in the large muscles begins to make its contribution. On the other hand, in weight profiles for boys who show a strong tendency to store fat,

the contribution of the other tissues may be almost completely masked by the changes in the fatty tissue component. Even when this occurs, however, the weight profile tends to follow the four phase pattern.

SEX-APPROPRIATE DEVELOPMENT

Rapid development of the external genitalia is perhaps the most striking phenomenon of adolescent growth in boys. Yet despite the interest in this aspect of puberal metamorphosis there are very few data concerning the successive stages of development through which the male genitalia pass in progress toward mature structure and function. For the most part, efforts to distinguish the successive phases have been centered upon changes in the character and distribution of body hair upon the meagerly supported hypothesis that certain of these changes correspond rather precisely to specific stages in gonadal and spermatogenic development.

From the study of seriatim photographs for more than a hundred adolescent boys as well as from the ratings of their pubic hair changes, we can begin to fill in some of the gaps in our knowledge of this important phenomenon by relating specific phases of genital growth to specific phases of other aspects of somatic growth.

With but few exceptions the male testes start their course of accelerated increase in size in the brief time zone which includes the prepuberal onset for leg length and stem length. The glans penis commences its puberal growth spurt at or very close to the onset of the puberal period for height. The glans penis growth ends its spurt about six months prior to the end of the puberal period for height. The testes end their period of rapid growth about a year after the end of the puberal period for height. This is usually before the close of the postpuberal period. During late adolescence (Phase IV) the external genitalia increase in size but slightly, the increase being gradual and at a low rate for several years.

Generally speaking, pubic hair tends to show rapid development toward adult characteristics at about the same time that the glans penis is in the stage of rapid growth. However, the range of individual variation is much greater for pubic hair ratings, which seem to be related to general body hairiness and to hair complexion as well as to developmental status. The unreliability of pubic hair ratings is also due to the fact that individual boys differ greatly in the length of time which elapses between one rating and the next. In any event, the onset and end of the growth spurts for testes and for glans penis show a much more consistent timing relation to the flexions of the phase pattern and also to specific skeletal age ratings of X-ray photographs of the hand and knee.

INDIVIDUALITY IN SOMATIC GROWTH

With but few exceptions past studies of somatic growth in adolescent boys have been based upon cross-sectional data at specific chronological ages. From such studies interesting central tendencies emerge. But when the growth profiles of a hundred boys are compared, it becomes evident that many of the conclusions drawn from statistically treated cross-sectional data grouped by chronological age require a good deal of supplementation before they can be applied to any given individual boy.

The systematic study of the process of growth as it occurs in a considerable sample of adolescent boys emphasizes not only the uniqueness of each individual's *status* at any chronological age but also the idiomatic nature of the *process* in each individual. In every aspect of development the manifestations of this individuality multiply as the frequency and variety of data collection are increased. The systematic relatedness of growth phenomena *in the individual* becomes more impressive as evidence of differences in growth dynamics *among individuals* accumulates. The patterns of change in skeletal dimensions, subcutaneous tissue, muscular tissue, body hair, genitalia, muscular strength, and body weight show that whatever may be the similarities in growth achieved at the end of adolescence they do not mean identity or even similarity of growth experience.

Among these individual differences in growth experience are those of timing in relation to chronological age, duration of corresponding phases of development, growth profile configurations, timing sequence patterns for specific growth phenomena. For some boys puberal growth is rapid and dramatic, for others it is of moderate intensity and long duration, for a few it is both intense and long, for other few it is neither long nor intense. There are boys in whom apex rates for many aspects of growth tend to occur with a high degree of synchrony, but there are also boys in whom the major spurts in these same aspects of growth are scattered through a span of four years or more.

Concerning the interacting causes for this diversity of the growth process we know very little, but certainly we may conclude that they cannot be explained simply as due to changes in the balance of endocrine products simultaneously available through the circulation to all parts of the body. There must be differences in selective readiness as between tissues and between areas. Probably the timing of the sequential stages for any part or tissue is determined partly by its inherent characteristics and partly by differential effect of growth processes in other, perhaps adjacent, parts or tissues. Thus, the endocrine stimulation which in one field of readiness may

start prompt growth response, may in another field be impotent or may even contribute to deceleration.

THE GENERAL SEQUENCE OF SOMATIC GROWTH PHENOMENA

Because the corresponding phases of the several aspects of adolescent growth in an individual do not occur synchronously it is not possible to define simply and exactly a prepuberal period, a puberal period, and a postpuberal period. However, it is possible to list growth phenomena which are characteristic for each period and which, when considered together, permit the examiner to make a clinically useful appraisal of maturational progress. In a sense these criteria constitute a new sort of time clock for somatic development.

The prepuberal period is a transitional period which, typically, lasts for from one to two years and includes:

A major portion of the distinctive Phase I pattern for stem length, hip width, and shoulder width
All of the Phase I pattern for leg length
The beginning of the Phase I pattern for weight and muscular strength
The beginning of the early adolescent increase in subcutaneous tissue
The beginning of the adolescent acceleration of testes growth
The appearance of unpigmented down (vellus) in the pubic area
Skeletal age ratings from 11.5 years to 13.5 years. (Todd)

The puberal period is the period of outstanding puberal development which, typically, lasts from 2.5 years to 3.5 years and includes: [1]

A major portion of the Phase II pattern for height, leg length, stem length, hip width, shoulder width, and weight
The beginning of the Phase III pattern for leg length
The first half of the Phase II pattern for muscular strength
The latter part of the early adolescent fat period
The middle two thirds of the adolescent spurt in testes growth
All of the puberal spurt in growth of glans penis
The major portion of the development of pigmented, wavy terminal hair in the pubic area
Skeletal age ratings from 13.5 years to 16.5 years. (Todd)

The postpuberal period is a period of transition which, typically, lasts for from one to two years and includes:

A major portion of the Phase III pattern for stem length, hip width, shoulder width, and weight

The end of the Phase III pattern for leg length
The latter part of the Phase II pattern for muscular strength
Slight but definite increase in subcutaneous tissue
The end of the adolescent spurt in testes growth
The spread of pigmented terminal hair to areas adjacent to the pubic escutcheon
Skeletal age ratings from 16.5 years to 18.5 years. (Todd)

The late adolescent period is a period of intermittent low rate development. The data available from this study yield information concerning only the early part of this period. It is highly probable that, typically, the period lasts for at least two years and includes:

A major portion of Phase IV for height, stem length, leg length, hip width, shoulder width, and weight
The last portion of Phase III and Phase IV for muscular strength
Development of pigmented facial hair terminals
Development of pigmented hair terminals over chest and thighs in many individuals
Skeletal age ratings from 18.5 years to 19.0 years. (Todd)

IMPLICATIONS FOR PROFESSIONAL WORKERS

The findings of this study of the somatic growth of adolescent boys would seem to carry implications of special interest to research workers in child development, to pediatricians, to school physicians, to guidance specialists, and to school administrators.

Procedures and methods for recording development. In the procedures used by schools and physicians for recording somatic growth, emphasis should be shifted *from* the individual's relation to the group average at a given chronological age *to* his stage of maturity in relation to the typical sequence of developmental phenomena. If group averages are desired they should be based upon growth achieved at corresponding developmental stages. For understanding the growth process of an individual, the outstanding peculiarities of his own pattern should be determined.

This approach requires the careful systematic accumulation of growth data at regular intervals over a period of years, which involves practical difficulties. For child development research a good many investigators find it possible to arrange for such continuity, and it could be arranged by many school systems for a limited number of items. To secure data for useful developmental appraisal the following procedures are suggested:

1. Measurements of height, stem length, weight, and muscular strength at six month intervals

2. Standardized front view photographic record each time the measurements are taken
3. Records in profile form on cross-sectional paper of the rate of change in height, stem length, leg length, weight, and muscular strength
4. Arrangement of photographic records for easy comparison.

From such data, so arranged, the investigator can identify the typical sequential phases of adolescent skeletal growth as they emerge, the onset and end of the puberal growth acceleration for testes and glans penis, and the peak of the early adolescent fat period. From the consideration of the relation of these phenomena an appraisal of somatic development can be made.

Practical uses of growth profiles. In every relation in which adults accept responsibility for selecting developmentally appropriate experiences for a child, these experiences should be chosen partly upon the basis of the unique sequential pattern of change through which that child has lived. A few examples chosen from different fields of adult responsibility may serve to illustrate this implication.

Whether a sixteen year old boy who is tall, heavy, and muscular for his age should participate in interscholastic football competition should depend partly upon his previous growth pattern. When did he commence his puberal growth? Does his pattern tend toward synchrony or asynchrony of development? Has he shown great or small fluctuations in growth rate? Has development in muscular strength lagged behind growth in weight? Did he experience a marked early adolescent fat period?

Whether a twelve year old boy whose academic achievement is falling off should be coerced into greater effort or be permitted greater leeway in the quantity and quality of school work should be decided partly from his physical growth profiles. Is he an early or a late developer? Has he been retarded in his progress toward sex-appropriate maturity?

For determining whether a fifteen year old fat boy should be given specific endocrine therapy, the bone age rating might well be supplemented by data from the growth profiles. What has been the general level of fatty tissue production? Is he in his early adolescent fat period? Has he reached the apex of his height growth velocity? What has been his pattern of growth in muscular strength, in testes development, in glans penis growth, in skeletal growth? Attention to developmental history and status is often as rewarding to the diagnostician as attention to disease history. From the experience of this particular study it seems very probable that many boys pass through a period of early adolescent obesity and, without any specific treatment, attain acceptable sex-appropriate physique in late adolescence.

The use of somatic growth data in relation to emotional and social development data. There is general agreement among those who have studied the changes in emotional and social orientation which occur during adolescence that among these changes is a new awareness of self which was not present during childhood years. Observations of boys who are experiencing early adolescent changes in skeletal dimensions and proportions, whose soft tissue contours are undergoing obvious and frequently unflattering alteration, and whose procreative ripening focuses attention upon specific sexual characteristics, indicate that during adolescence the physical aspects of self play a major role in determining the degree of self-acceptance. The degree of self-acceptance, in turn, is an important factor in molding emotional attitudes and social behavior.

Thus, the consideration of an adolescent's somatic growth process may furnish useful information concerning sources of tension in his personality structure, and such tensions may persist even after the individual has recognized intellectually that self-acceptance can be achieved in spite of an unsatisfactory body.[2] This use of somatic growth data is illustrated in "The Case of Ben" in Chapter XVIII.

FOOTNOTES FOR CHAPTER XVII

1 When adequate cumulative measures and observations are available, the characteristics of the first and second halves of the puberal period can be differentiated. (See Chapter XVIII.)

2 See Stolz, H. R., and Stolz, L. M.: "Adolescent Problems Related to Somatic Variation," *43rd Yearbook,* Part I, National Society for the Study of Education. Chicago, 1944, Chap. V.

Chapter XVIII RELATION OF SOMATIC CHANGES TO OTHER DEVELOPMENTAL PHENOMENA DURING ADOLESCENCE: THE CASE OF BEN

THE TIME CLOCK OF DEVELOPMENT

IT has been pointed out by several investigators that during adolescence the individual is peculiarly aware of his body, and that one of his primary developmental tasks is the acceptance of his changing body as a symbol of his changing self.[1] This would suggest the possibility of a relation between the developing body and changes in emotional and social relations during adolescence. Since considerable data on social development were collected on each of the boys over the seven year period it was possible to study these data in relation to somatic development.[2]

From our analysis of somatic development presented in the previous chapters, it seems evident that during the accelerated growth period of adolescence chronological age cannot be used with any degree of reliability as an indicator of development. To say that a boy is twelve years old tells us very little about his somatic development. Chronological age is a measure of time lived and is therefore important from the point of view of experience. It also largely determines grade placement in school and gives some indication of the cultural characteristics of the peer group with whom the child associates. But during adolescence, when the body is the symbol of the self, a boy's responses to life and to the impact of peer culture may be largely determined by what is taking place within his own body.[3]

In addition, in homes, schools, and the community, generalizations are built up regarding the expected behavior of boys of a given chronological age. Twelve year old boys, for instance, are expected to have different interests and to act differently than do boys of fourteen. When a boy develops during adolescence at a rate which approximates the group mean and when he associates with boys of about his own developmental level, it is easy for him to adjust to such expectancies. However, when there is a marked discrepancy between the cultural expectancy, based on chronological age, and a boy's maturational readiness, problems are apt to arise

both for him and for society. The understanding of such problems will be the first step toward their solution.

Therefore, because of the difficulties inherent in using chronological age as a basis for analyzing development during adolescence, we wished to discover whether the four periods of somatic development suggested in Chapter XVII might be useful as a new time clock to which might be related other phenomena.

As a preliminary step we tentatively analyzed the data regarding the social development of several boys in relation to the prepuberal, puberal, postpuberal, and late adolescent periods of development as determined by the individual somatic growth pattern of each boy.[4] The social data included a variety of observations, ratings, personal inventories, interviews, and the like.[5] The analysis of these personal and social data in relation to specific stages of somatic development seemed to give them more meaning than did analysis in terms of chronological age alone.

We have selected one case to present in this chapter as an example of how the four periods of development within adolescence, as defined in the previous chapter, might be used as a base line for studying changes in social behavior. In selecting the "Case of Ben" for presentation we were influenced by several considerations:

First, he clearly exemplifies the characteristic changes in somatic growth which occur during adolescence.

Second, the changes in his personal-social relations bear a close relationship to the timing and the configuration of his somatic growth pattern.

Third, being a very early developer he illustrates dramatically the problems which may arise because of a discrepancy between cultural expectancy and maturational readiness.

BEN'S SOMATIC DEVELOPMENT DURING ADOLESCENCE

When he came for his first examination in the spring of 1932 Benjamin Ruppert * attracted attention as an upstanding, pleasant, friendly boy with dark eyes and hair, a slightly swarthy complexion, and skin texture that tended to be coarse but free from any blemish. He was one of the youngest boys in the high fifth grade. Ben was not only young for his grade and group, but he was what we call an "early developer." His mother reported that his height, weight, and strength during childhood had always been definitely above average.

* All names in this presentation are pseudonyms, and identifying personal data have been altered.

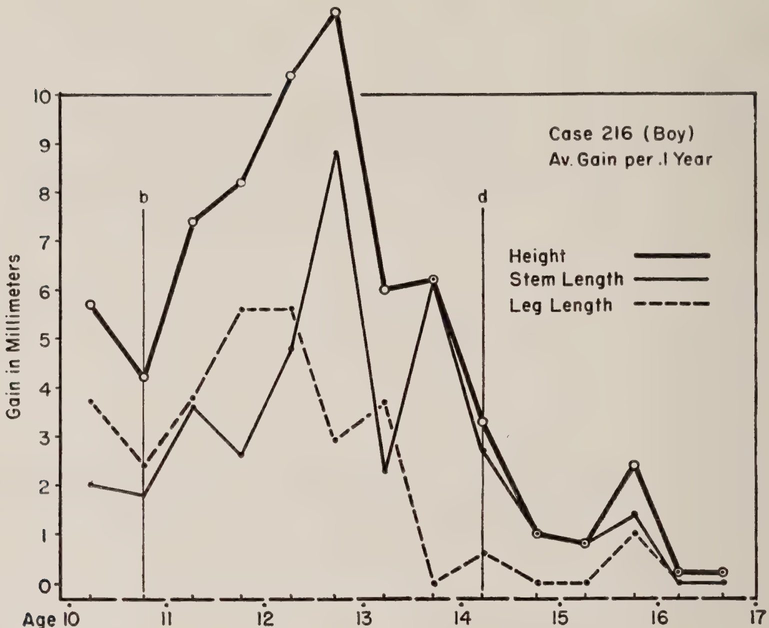


FIGURE 195a. Ben was an early developer who began the puberal period for height growth at 10.75 years of age and completed it at 14.20 years. He gained 10.48 inches in height during the 3.45 years.

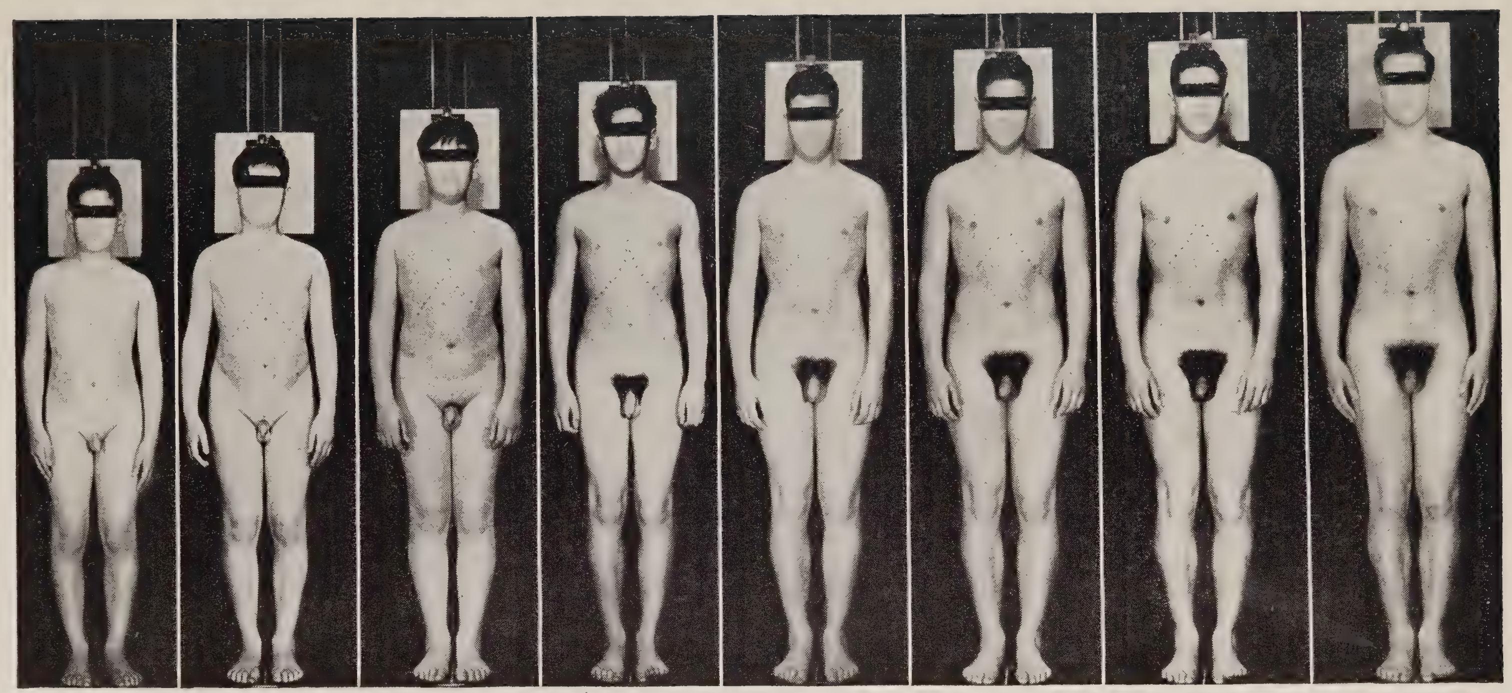
GROWTH IN HEIGHT

When Ben was ten years old he was four feet, eight inches tall; seven years later he was five feet, nine inches.[6] The rate at which he acquired the thirteen inches during those seven years is shown in Figures 195a and b.

Before Ben was eleven years old he had begun the rapid growth in height which is characteristic of the puberal period. Shortly after fourteen years of age he completed his period of rapid puberal growth. Ben had gained 10.5 inches in height during these three and a half years.[7]

In timing of growth in height Ben was precocious—one of the earliest to begin and to complete the puberal growth spurt. Only 1 boy of the 67 on whom we had complete records was more precocious; only 4 of the remaining 26 for whom we can estimate the onset of puberal development were probably more precocious. He had completed his main growth in height at a time when 3 per cent of the cases had not yet begun the puberal period, before 40 per cent of the boys had reached the apex, and before 94 per cent had completed their puberal growth in height. This is dramatically shown in Figure 33a on page 61 where the height curves for Ben and for a late developer are shown together.

Ben had a long puberal period of height growth, as is not uncommon in early developing boys.[8] The apex of his growth in height occurred near the



C.A.	9.9	11.0	12.0	12.9	13.9	15.0	16.0	16.9
Sk.A.				14.50	16.0	16.75	18.0	18.25

FIGURE 195b. Photographs of Ben at yearly intervals. At 9.9 years he was well nourished, but not fat. His breadth of shoulder was already apparent, and in other respects he was acceptably masculine. A year later, his early adolescent fat period was beginning, and at twelve years he had even more excess fat. At 13 years his fat period was over. The rapidity of his growth from 11 to 14 years is evident. Rapid growth of testes commenced before age ten. Rapid increase in glans penis, from 11.5 years to 13.9 years, extended over a shorter period than puberal growth in height. Development of pubic hair was most rapid from 12.5 years to 13.9 years, but the escutcheon area increased up to 17 years.

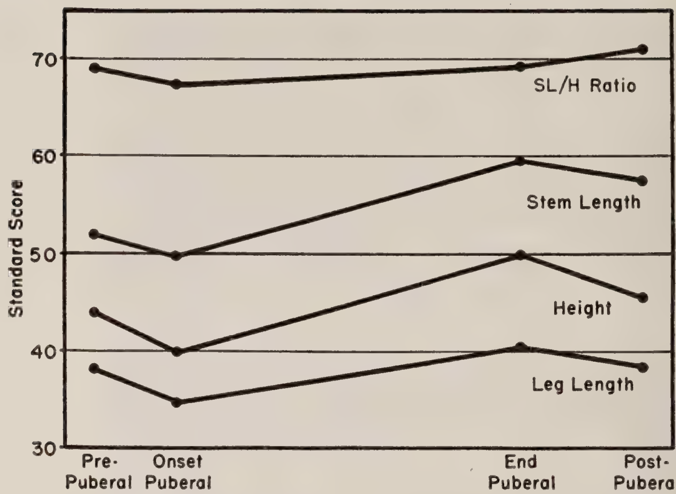
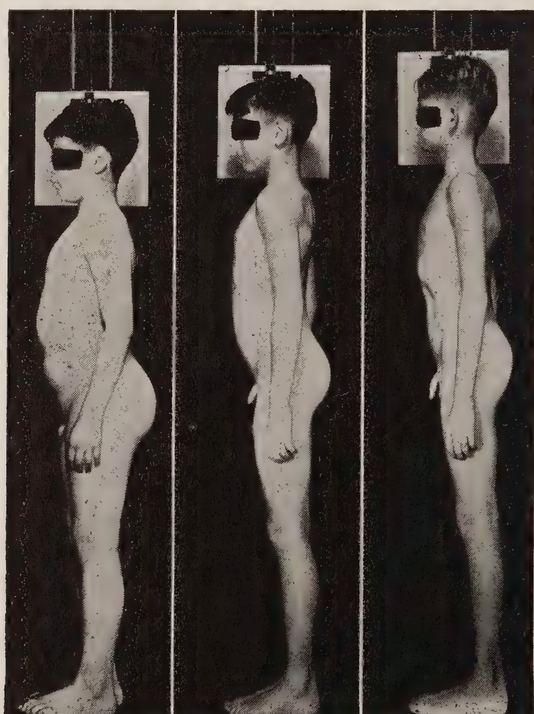


FIGURE 196. Relation of Ben's length measurements to those of other boys at similar developmental points. Actual measurements have been converted into a score to show relative position in the group of boys. A score of 50 is average; ten points on the scale equal one standard deviation from the mean.



Ben **Case 34** **Case 52**

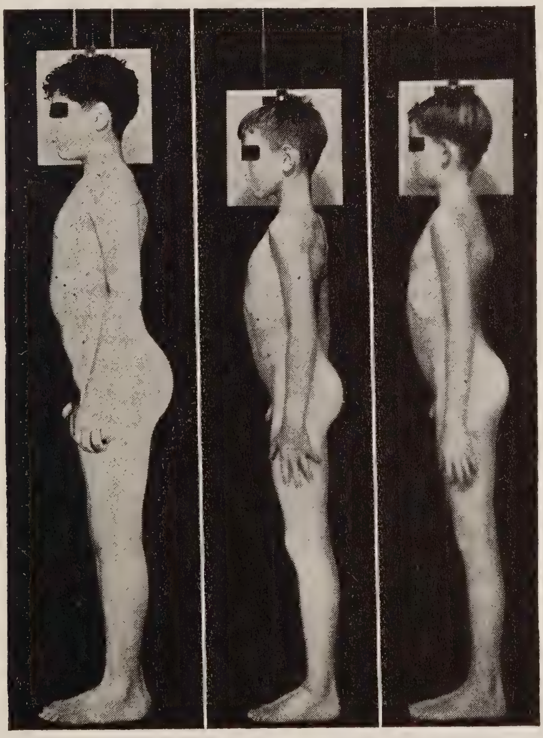
FIGURE 197a. Ben was less than average in height among boys who were at the same developmental level except at the close of the puberal period. These photographs were taken at the examination just following the onset of the puberal period.

mid-point of the period, as was true in two thirds of our cases. It is interesting to note, however, that his growth curve did not follow the usual configuration. His pattern showed a short period of acceleration in rate during the second part of the puberal period.[9]

His height was less than the average for our sample at the onset and, in spite of a large gain, was still below the average at the end of the puberal period. (See Figure 196.) The fact that Ben seemed tall among his classmates was due to his early maturing. Actually, he was only five feet, nine inches tall at seventeen years. (See Figures 197a, b.)

There were few boys who gained as much in height during the puberal period as did Ben. This was related to the fact that he was an early developer and had a long puberal period.[10] At the onset of the puberal period Ben had gained only 83 per cent of his height at seventeen years; by the end of the period he had gained 98 per cent of his final height.

Ben was always a boy of relatively long trunk and short legs, and this became more pronounced as adolescence progressed. When he was first



Ben **Case 34** **Case 52**

FIGURE 197b. Ben seemed tall among boys of his own age because he was an early developer. These photographs were taken of the same boys who are shown in Figure 197a when Ben was 12.5 years old and the other boys were 12.4 years of age.

examined the rate of growth of his legs was increasing, a phenomenon characteristic of the prepuberal phase of development. This is evident in Figure 195a. During the first part of the puberal period the increase in leg length contributed most to his height; during the latter part stem length made the predominant growth.[11]

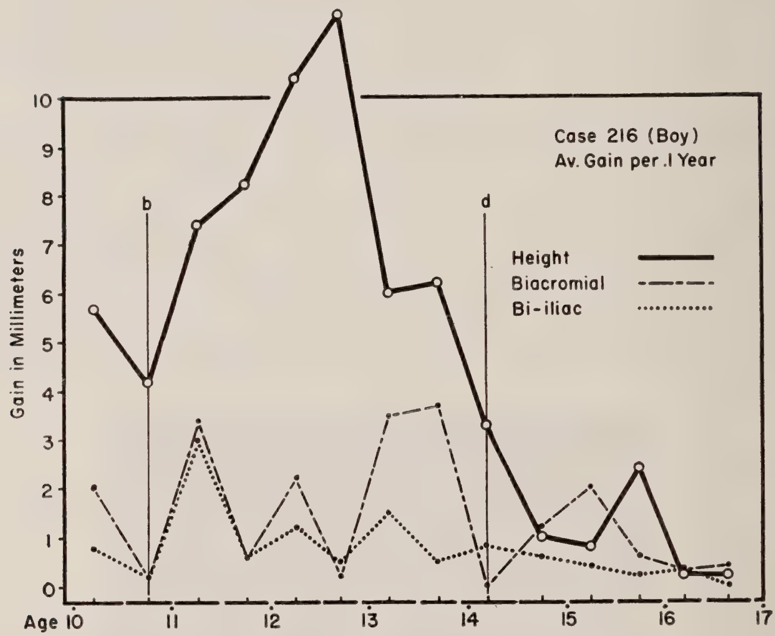


FIGURE 198. Ben had a spurt in growth in body width at the beginning of the puberal period. Following this, hip width had only intermittent low-level growth. But his shoulders made large gains, characteristic of adolescent growth, with the apex of growth toward the close of the puberal period.

The rhythm of growth of stem length and leg length can be seen in Figure 195a. Except for one six month period, the rate of growth for stem length increased as the rate for leg length decreased or stem length rate decreased as leg length rate increased. About one fifth of our cases showed similar lack of correspondence.[12]

Relation to skeletal age. The precocity of Ben's development is further verified by his skeletal age ratings during the last four years of the seven year period. Just after he had passed the apex of his puberal growth in height his skeletal age was 14.50 years, when his chronological age was 12.9 years. Even for this point in development Ben was .84 year advanced over the mean for the group. Only seven per cent of the boys were as accelerated in skeletal age as this.[13] At the end of his puberal period for height Ben's skeletal age was 16.0 years, while his chronological age was

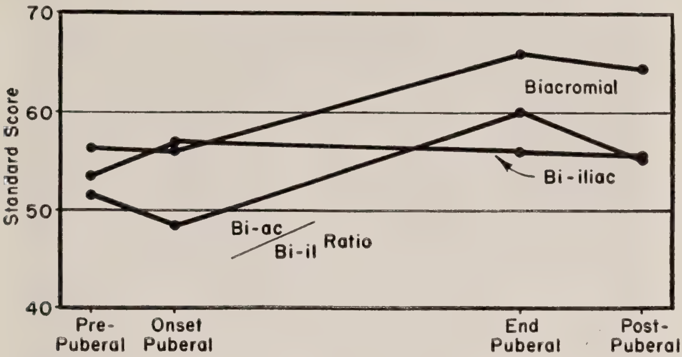


FIGURE 199. Relation of body width measurements of Ben to those of other boys at similar developmental points. Ben was a broadly built boy throughout. During adolescence his shoulder-width/hip-width ratio increased significantly. (A standard score of 50 is average.)

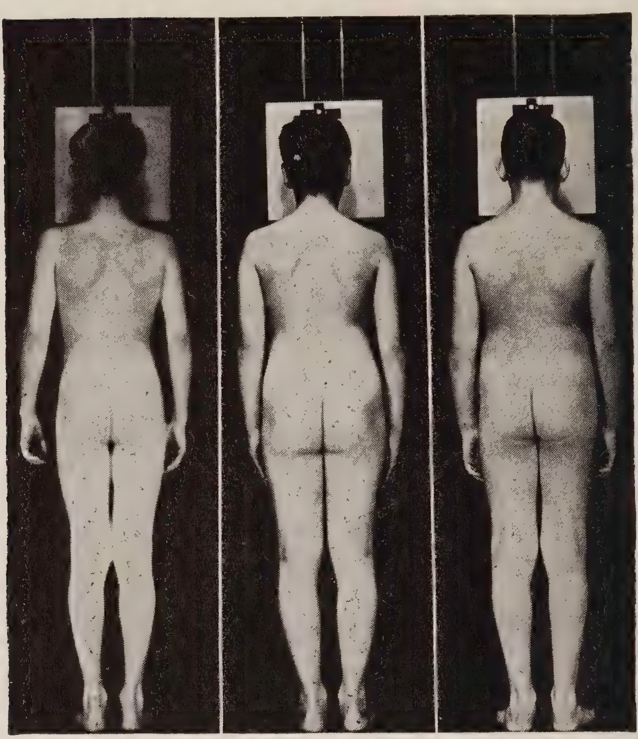
14.2 years. At 16.5 years of age he had completed his skeletal growth as indicated by bone development.[14]

GROWTH IN BODY WIDTH

Throughout the period of our study Ben was a broad-built boy. At the onset of the puberal period the rate of development for both hip width and shoulder width increased simultaneously. (See Figure 198.) The early puberal spurt marked the apex for growth in hip width.[15] He gained over half an inch in six months.[16] There were only three boys who gained more than this in a similar length of time. After the early part of the puberal period Ben gained very little in hip width. His profile of growth shows a rhythm of acceleration and deceleration every six months, but at a low level. Ben's hips were broader than the average at every period. However, he gained slightly less than average during the puberal growth period.

At the beginning of the puberal period he was broad in shoulders for his chronological age as he was tall in height. In comparison with boys of the same developmental maturity he was, however, only slightly above average. (See Figure 199.) During the puberal period he gained 2.9 inches in shoulder breadth; this placed him among the seven per cent of boys who made the greatest gains. At the close of the puberal period he was among the upper nine per cent in shoulder breadth. By the time he was seventeen years old several boys who were slower in development caught up and surpassed him in shoulder width, so that there were twelve per cent cf the sample who had wider shoulders than he. At this final examination Ben's shoulders measured 16.3 inches.

His growth in shoulder width is marked by a rhythm of acceleration and deceleration every six months, except for the year preceding the close of



Case 10 **Ben** **Case 88**

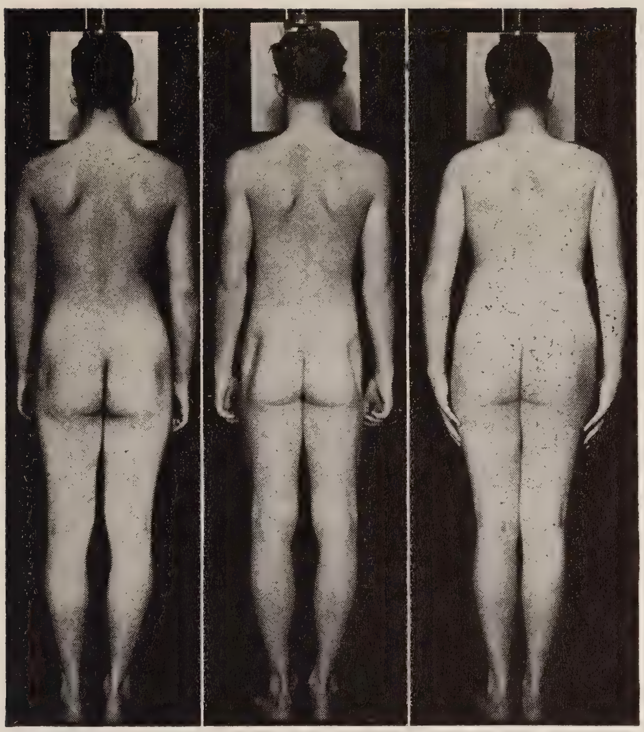
FIGURE 200a. Ben was average in shoulder/hip width ratio at the onset of the puberal period compared with boys of the same developmental level. Case 10 had the highest ratio in the group; Case 88 was among the boys having the lowest ratio.

the puberal period. That was the time of his maximum growth in shoulder width.[17] The amount of gain at the apex is below the median, probably owing to the fact that this increase in rate was prolonged over a year without recession.[18]

Shoulder/hip width ratio. From comparison of the growth of Ben's hip width and shoulder width it can be seen that his width growth showed an increasingly sex-appropriate trend—toward relatively broad shoulders and narrow hips. From being at the average in shoulder/hip width ratio at the onset of the puberal period, he ended the period among the fifteen per cent with the highest ratio. (See Figures 199 and 200a and b.)

CHANGES IN SUBCUTANEOUS TISSUE

As is evident in all his photographs, Ben was "well padded" throughout the seven year period. This is substantiated by his relative position in the group as shown in Figures 201 and 202. At the first examination Ben was among the fifteen per cent with highest ratings in subcutaneous tissue, and



Ben **Case 8** **Case 66**

FIGURE 200b. Ben was among the highest fifteen per cent in shoulder/hip width ratio at the end of the puberal period compared with boys of the same developmental level. Case 8 had an average ratio, Case 66 a low ratio.

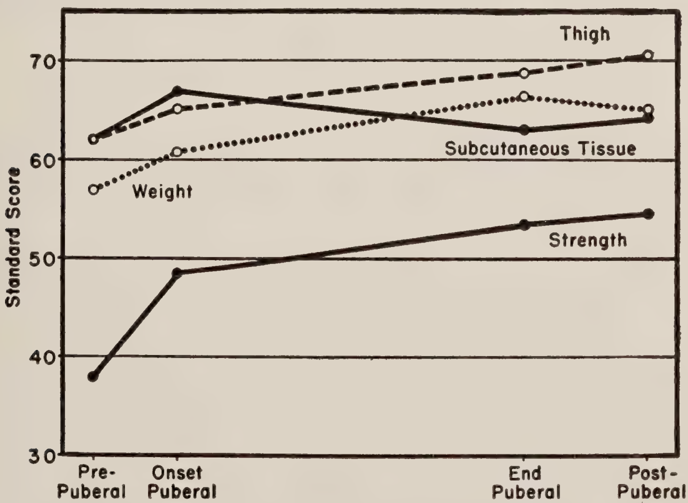
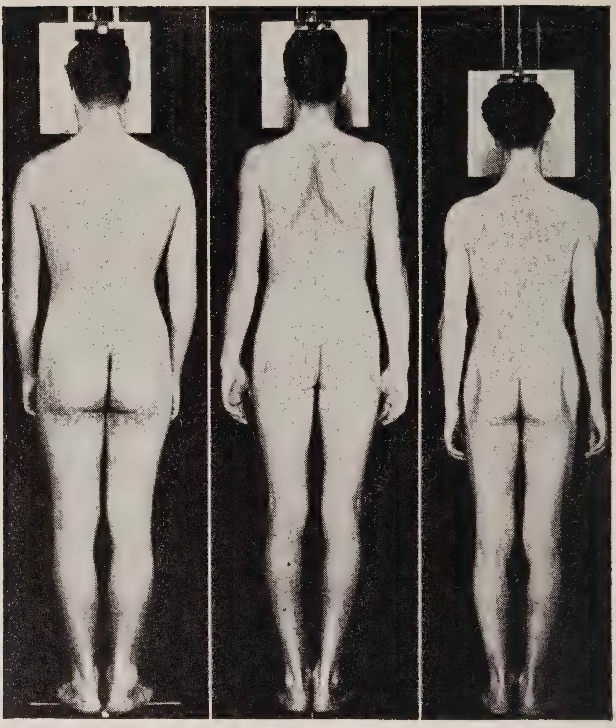


FIGURE 201. Relation of measurements of body mass and strength of Ben to those other boys at similar developmental points. The discrepancy between his body bulk and strength at every point can be seen. (Standard score of 50 is average; ten points on the scale equal one sigma.)



Ben C.A. 15.4 | **Case 42** 15.9 | **Case 60** 15.9

FIGURE 202. Ben was "well padded." Here he is when he was in the low eleventh grade, with two other boys representing average and low subcutaneous tissue ratings. All three boys were in the postpuberal period.

at the last examination there were only two boys who exceeded him.[19] His subcutaneous tissue ratings consistently placed him among the upper 25 per cent of the group.[20]

The changes in the amount of subcutaneous tissue followed the developmental pattern generally found in the puberal growth period. There was a rhythm of increase to onset of the puberal period, followed by decrease during the period, followed by increase during the postpuberal period. These developmental swings are evident in the photographs of Ben. (See Figure 195b.) In quantitative terms the sum of subcutaneous measurements on arm, abdomen, and hip varied as follows: at first examination, 2.24 inches; at puberal onset, 2.60 inches; at the puberal close, 2.24 inches; at the final examination, 2.79 inches.[21]

In Figure 203 the changes in *rate* of gain and loss in subcutaneous tissue index are shown.

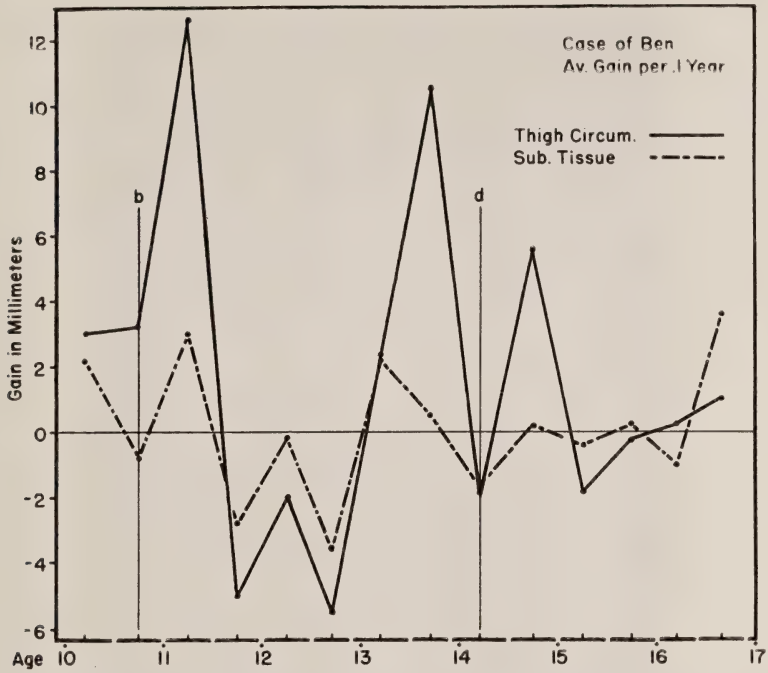
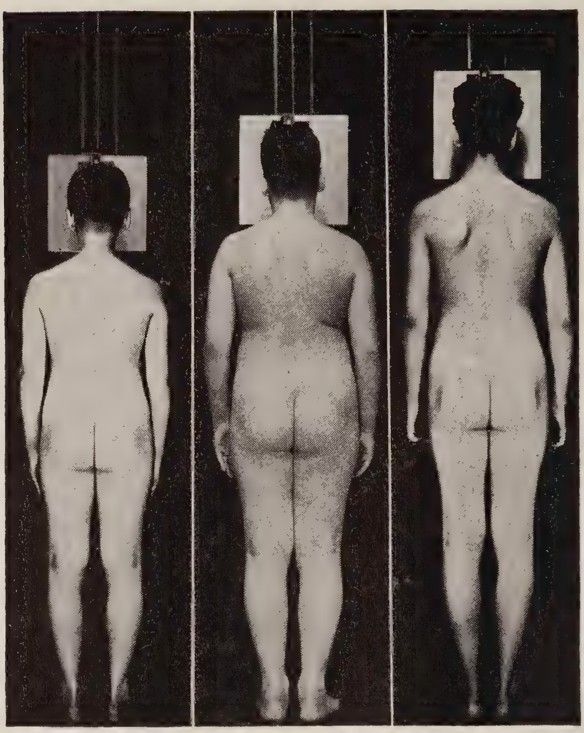


FIGURE 203. Both in thigh circumference and in subcutaneous tissue index Ben manifested marked profile fluctuations. These fluctuations showed striking parallelism until toward the end of the puberal period when the muscular growth component of thigh circumference became predominant. Late in the postpuberal period Ben's subcutaneous tissue index again showed an increase.

Early adolescent fat period. Ben was one of the 21 boys who went through a strikingly obvious early adolescent period. He was one of the 8 who were unmistakably disturbed by this extreme increase in fat. The period lasted from about the beginning of the puberal period for height to the center of the period, when Ben was between 10.75 and 12.75 years of age. The increased obesity consisted not only of generalized addition of subcutaneous fat over face, body, and limbs but also of an accentuation of such tissue in the mammary region, the pubic region, and over hips and buttocks. The subareolar increase suggested a feminine type of breast development, and the increase on the inner surfaces of the thighs also suggested feminine contours. At the height of the fat period (11.5 years) the increase of fat about the neck, cheeks, and jaw strikingly altered his facial appearance. Combined with the rapid increase in hip width and in leg length (previously mentioned) the early adolescent fat increase gave him broad-hipped, short-waisted body lines which are particularly disturbing to a boy with masculine aspirations. (See Figure 204.)

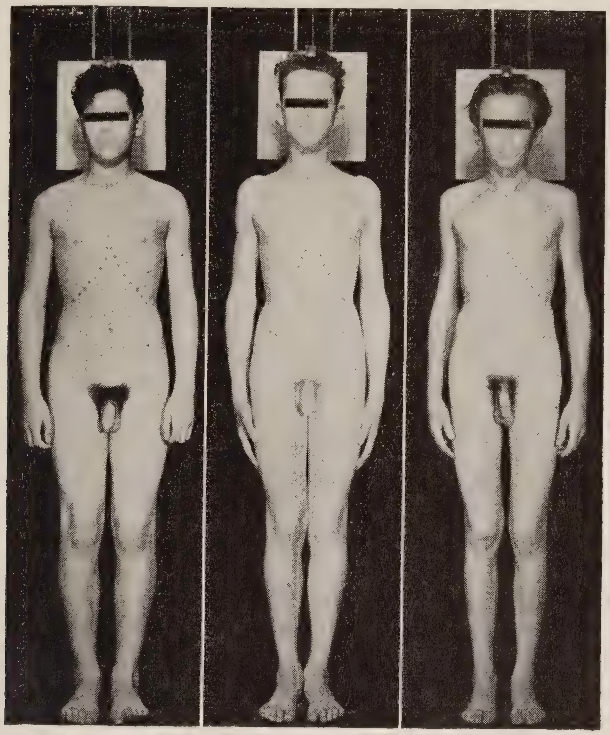


C.A. 9.9 11.5 12.9

FIGURE 204. These photographs of Ben show him just prior to, during, and just after his early adolescent fat period. For him the fat period lasted from about 10.75 years to about 12.75 years.

GROWTH IN THIGH CIRCUMFERENCE

Ben's measurement in thigh circumference was among the highest twelve per cent during the prepuberal period. It gradually increased not only in actual but also in comparative size until he was among the highest five per cent in the postpuberal period. (See Figure 201.) The profile of his growth in thigh circumference shows close similarity in flexions to his curve in subcutaneous tissue ratings until the postpuberal period. (See Figure 203.) Note the rapid increase in both these measurements between 11 years and 11.5 years, at the height of his fat period. Following this, he lost in both of these measurements for a year and a half. Although in Ben the fat component of thigh circumference was relatively large, we must not overlook the fact that in the latter part of the puberal period and the first part of the postpuberal period there was a significant increase in the muscular component. (See Figure 205.)



Ben **Case 184** **Case 190**

FIGURE 205. Ben had large thighs. This is a comparison of him with two other boys who had relatively small and medium thigh measurements. Photographs were taken immediately following the puberal apex in height growth for each boy.

CHANGES IN WEIGHT

This boy was large boned, muscular, and well supplied with subcutaneous fat. It is not surprising that he was one of the heaviest boys. He was among the highest fifteen per cent until toward the end of the puberal period when he joined the highest eight per cent. (See Figure 201.) All the boys who weighed more than Ben evidenced a marked fat increase during the early part of the puberal period. Most of these boys were among the tallest boys in our group, but Ben was consistently below average.[22]

The profile for his changes in weight over the seven years shows his major increases occurring within the puberal period, which was typical. There were two peaks of increase, one during the first part of his fat period and another long but less dramatic rise during the latter half of the puberal period. The timing of these increases parallels increases in subcutaneous tissue and thigh circumference. The data indicate that while the first in-

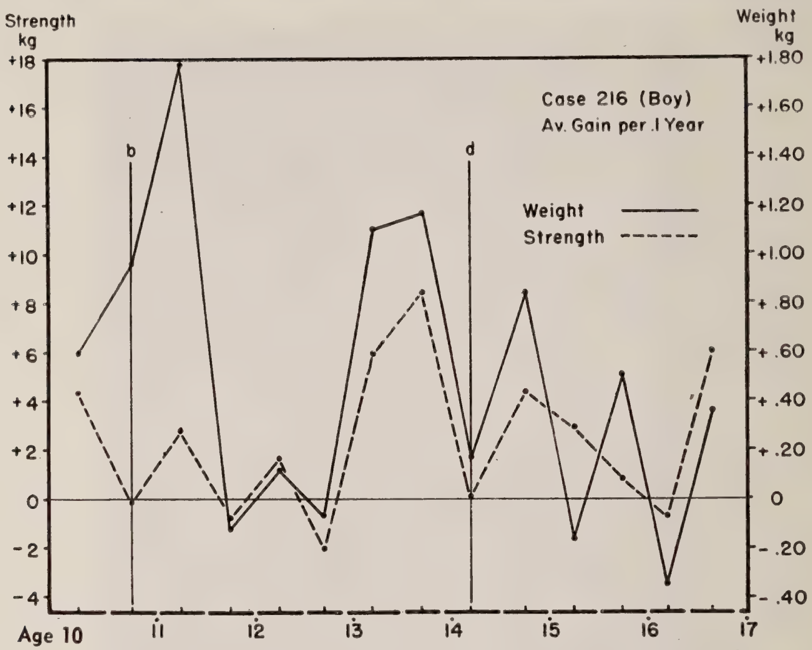


FIGURE 206. Ben's weight and strength growth showed an unusual degree of synchrony. In the majority of boys increases in strength growth followed increase in weight. However, Ben made less growth in strength during the postpuberal period than most boys and thus lost his earlier advantage. (Strength score was a summation of four measurements. See Chapter XIII.)

crease was due predominantly to an increase in fatty tissue, the second represented more especially increase in muscular tissue. (See Figure 206.)

Ben showed occasional instances of actual loss in weight. Such losses occurred in two thirds of our boys. However, Ben lost weight four times, and there was no other boy who lost weight so often. The postpuberal losses may have been due to football practice in the fall or the four losses may be a peculiarity of this boy's fat metabolism.

GROWTH IN STRENGTH

During the latter part of the prepuberal period Ben lacked the muscular strength which might be expected from a large, well-built boy. But by the beginning of the puberal period he had improved his relative position in the group from the lowest quartile to just below the median. After that he made no major increase in strength until the latter part of the puberal period when he was out of his extreme fat phase. This puberal gain raised him to above the average. (See Figure 201.)

Thus, in four years Ben's strength had increased greatly, and his position in the group had improved considerably. Most of the boys changed their

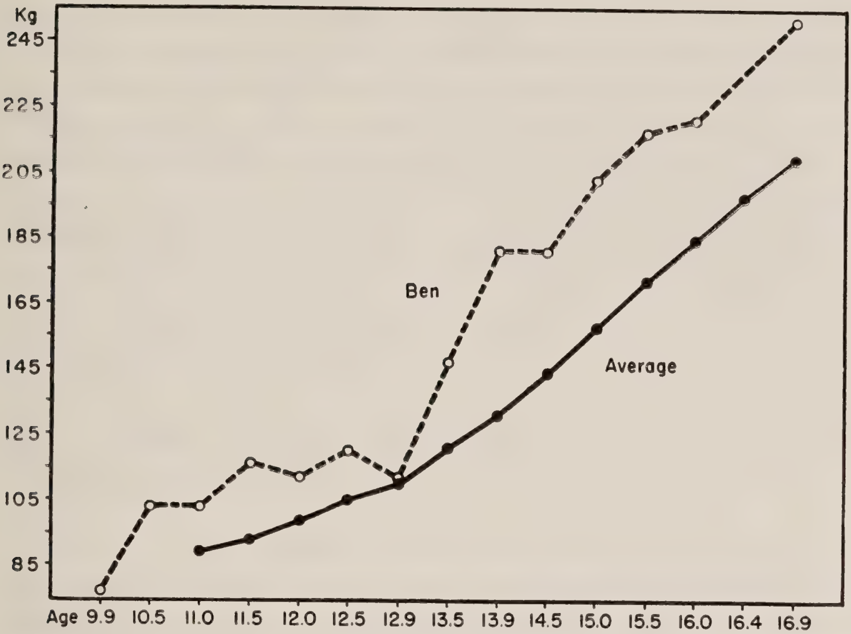


FIGURE 207. Ben had an enviable position in strength compared with other boys of the same chronological age. This is in marked contrast to his comparative strength with boys of similar developmental status. (See Figure 201.) Ben made little gain in strength during his early adolescent fat period (from about 10.5 years to 12.5 years). His major gains were made following his puberal apex in height growth.

relative positions, and two thirds had their apex of growth in strength during the puberal period as Ben did. But unlike Ben, most of the boys made larger gains during the postpuberal period rather than during the puberal period. (See Figure 206.)

If we compare Ben's development in strength with that of boys of the same chronological age rather than the same developmental age, we get a different picture. (See Figure 207.) On this basis he was always above average, and from fourteen years of age on had an enviable advantage over most of his fellows. It was this discrepancy between chronological age and developmental maturity which led Ben's classmates—and Ben himself—to expect of him during his postpuberal period of development greater athletic prowess than he could achieve.

DEVELOPMENT OF PUBIC HAIR AND EXTERNAL GENITALIA

Important to several aspects of development during adolescence are the changes which take place in the maturing sex organs and related secondary sex characteristics. The order of Ben's development followed the most frequent pattern. Acceleration in testes growth began about nine months

before the onset of puberal growth in height, and acceleration in growth of the glans penis commenced three months after that point. Within a period of a year, testes, height, and glans penis began their rapid puberal growth. Unpigmented vellus hair had begun to show in the pubic area. At this time Ben was between 10 and 11 years old—one of the two youngest boys in this phase of development.

The accelerated growth for glans penis ended nine months before the end of the puberal height period; that for testes nine months after. Again this was the usual pattern. During the second part of the puberal period his pubic hair developed rapidly and, before the end of accelerated glans penis growth, had attained full density with terminals more than 25 millimeters in length. By the time Ben was fifteen years old he had completed his major growth in external genitalia and in pubic hair. This was a year and a half before even half of the other boys had reached such maturity.[23]

SUMMARY OF BEN'S SOMATIC CHARACTERISTICS

The outstanding characteristics of Ben's somatic development and those which seem to have special significance for his personal-social adjustment may be summarized as follows:

1. He was markedly precocious in the timing of his somatic growth.
2. He was of medium height for developmental age but was always considered to be tall because his classmates were slower in development.
3. He was broadly built. Both his hips and shoulders were wide in relation to his height.
4. His trunk was definitely but not extremely long in relation to his legs.
5. His shoulder/hip width ratio, about average at the beginning of adolescence, increased as he matured.
6. His large bones were well covered with muscles.
7. Throughout adolescence his subcutaneous fat layer was of more than average thickness. For about two years early in the puberal period he was encumbered with large amounts of fatty tissue. At other times fatty tissue did not significantly affect either his appearance or his activities.
8. This early adolescent fat period combined with growth acceleration in hip width and leg length to produce the most striking metamorphosis which Ben experienced during his adolescent years.
9. His muscular strength in relation to developmental maturity increased from below to above average during the adolescent years. Because of his precocity in development he was always considered extremely strong in comparison with boys of like chronological age.

10. His body type at age seventeen, according to the Sheldon rating scale, showed a definitely predominant mesomorphic component, an average endomorphic component, and an unusually low ectomorphic component.
11. Except during his early adolescent fat period he was strongly masculine in general appearance. He was broad-shouldered and straight-legged; his hands and feet were rather large; he was muscular and fairly strong; his genitalia were well developed and he tended to be hirsute. During his fat period the excessive layer of subcutaneous tissue masked his masculinity and gave the impression of sex-inappropriate development.

BEN'S SOCIAL DEVELOPMENT DURING ADOLESCENCE

THE PREPUBERAL PERIOD

Somatic development. Ben was already in the prepuberal period when we first saw him. He had passed the dip in stem length growth, his legs had made their first spurt, the down of vellus hair had appeared in the pubic area, and his testes were beginning to grow.

Personal appearance. To adults Ben was an attractive-looking boy with a happy, pleasant expression. One observer described him:

> An extremely large boy, broad, tall, strong looking, well padded. Has a long face, amazing large golden-brown eyes, black lashes, and black, slightly curly hair, brownish skin, and lots of red in his cheeks.

The family situation. Ben was the oldest boy in a family of five children. At the beginning of the study Lotta was ten years old. Ben was nine years, Paul eight years, Margaret five, and Ferdinand, the baby, one year old.

The family was of mixed German and English stock. The parents had both been born and educated in South America, and German was the language spoken in the home. Mrs. Ruppert had gone to elementary school, but Mr. Ruppert had attended an academy, preparing to be a teacher. He had never become a teacher, however, but had gone into business. For several years he had been connected with a commercial firm.

Mr. Ruppert was a man of many interests. Besides English and German he spoke French and Spanish and understood some Portuguese. He liked to tinker with machines and had a flair for making radios. He read a great deal about history and radio. He did not care for the movies, and did not go to church. His only social contacts outside of his family and business associates were in a fraternal club which he attended rather regularly.

Mrs. Ruppert was a pretty, refined woman, rather young to be the mother of five children. She was devoted to her children, but family respon-

sibilities weighed rather heavily on her. Paul, the eight year old boy, had never been to school because he had trouble in walking and could scarcely talk. The mother's health was not good, and she had severe asthmatic attacks, especially when she was worried.

The depression beginning in 1929 had brought economic hardships to the Rupperts and emotional problems to parents and children. Before the depression Mr. Ruppert had earned $300 a month and large bonuses. But gradually this had been decreased until in 1932 he was earning only $130 a month. The family had to make many adjustments. They moved from a large metropolitan city to a smaller community. Their home now was a two-story dilapidated shingle house in an inferior residential neighborhood within a commercial area.

During the years of adolescent development the relations which Ben had with his family were important factors in his own emotional adjustment. How father and mother and brothers and sisters felt about Ben and his feelings toward each of them are difficult relations to analyze. However, we catch glimpses of these dynamic emotional interrelations from several sources.

Mrs. Ruppert stated that when Ben was in the prepuberal period he was so big and lively that he was hard for her to manage. "He is bright and into everything, but his father said he himself was much worse than Ben when he was the same age." However, there were few problems regarding the usual routines of eating, sleeping, clothing, and daily schedules. Sometimes Ben would cry himself to sleep when his mother would scold him for not going to bed right away. Occasionally, there was friction over home duties. But there were no serious problems, and the mother was not unduly worried or concerned.

According to the mother, the "family stick together," and Ben had few friends outside of the family group. He shared the same bedroom with his retarded brother, Paul, and played imaginative games with him. He took care of his small brother, Ferdinand. He quarreled most with his older sister, Lotta. Ben admitted that he fought with his brothers and sisters but wished that he didn't. He said that he was proud when they were praised. There seemed to be little evidence of jealousy but rather a genuine security in his feeling of belonging to this large family.

Ben at ten and a half years was carrying a heavy share of home duties, especially when his mother was sick with asthma; fixing his room, emptying garbage, washing diapers. In addition, he began his newspaper route at this time, and he and his family were very proud of this.

Just after his tenth birthday Ben added "my father" to a check list of fears.[24] This was about the time when Mr. Ruppert was out of work for

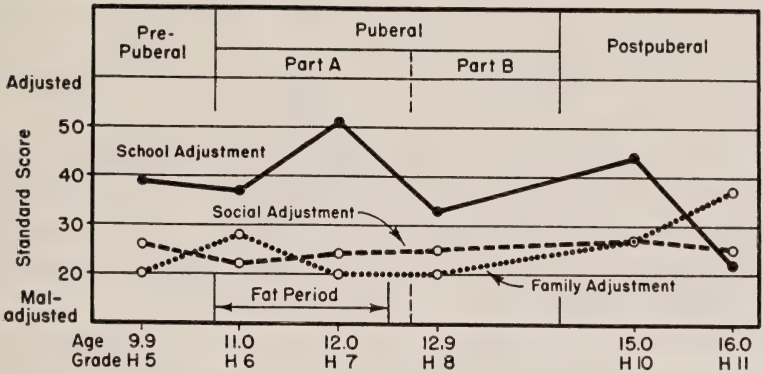


FIGURE 208. The responses which Ben made on the U. C. Emotional Inventory were scored in relation to responses of the other children in the Adolescent Study. His feelings about his family and about his relations with other children gave him consistently through the years one of the lowest scores of any child in the study. His feelings about his school life were in general higher but came near the average only in the high seventh and high tenth grades. His low score in the high eleventh came at the most difficult time in his school career.

three months following the death of his boss. But in spite of this fear, Ben said he loved his father best of all the family and wished he had more time to spend with him. In a questionnaire he stated that his father would be first choice for a companion if he were going to the circus or if he were going to live on a desert island.

Next in Ben's affections was his mother. He wished she could be happier and had better health. She was his second choice for circus or desert island. He said that he liked to go home and help his mother after school.

There were some areas of conflict over parental supervision. He couldn't stay out at night as late as he wished; he wanted to choose his own clothes but wasn't allowed to. But he stated that if he were worried he would always talk to his mother or father about it.

Ben reported that he dreamed quite often about his father, his mother, and his brothers and sisters. He said that he was afraid someone in the family might die.

These feelings about his family and his responsibilities toward mother and father and brothers and sisters gave Ben one of the lowest scores of any child on the emotional inventory.[25] (See Figure 208.)

Six months after Ben had made these revelations, when he was 10.5 years old, his mother said, "There has been a great change in Ben this year. He seems to be more grown up. His father is more companionable with him now. He treats him more like an equal. Ben plays with his father on Sundays. Ben takes aeroplanes that his father has made to bed with him. All the children are fond of their father, but they are scared of him too."

Relations with boys. The record of Ben's relations with boys before puberty is very sketchy but gives a few leads which may have significance in terms of his later development. Ben, in reporting on his previous school background, said that he started school in kindergarten but did not want to go because "there was not enough time for play." He had "fun in kindergarten," but he did not get along well because he "behaved badly," he "liked to talk and make bad people laugh." In the first and second grades he "was very mischievous as in kindergarten," but he added "Mother made me be good, or I wouldn't get any Christmas presents."

These memories of silly behavior which he reported may have expressed his feelings of inadequacy with other children and may be an indication of his efforts to gain attention and significance in a social situation.

However, on his first visit to the Institute, when he was 9.9 years old, we get a different picture. He was with one boy, Lanny, from his own school, and four boys from another elementary school—all older than he. He was described as "completely at ease and seemed happy and pleased with himself and the universe." He played with his partner, Lanny, with the puzzles, and chatted with him as they painted.

He had the normal interests of boys of that age—roller skating, playing ball, and interest in mechanics. His favorite game was football. He longed to own a bicycle, but such a gift was then beyond the means of the family.

His classmates (high fifth grade) considered him friendly—active in games, in leadership, and in fighting—all very desirable qualities among boys at this stage of development. They also thought of him as being restless, talkative, and unkempt, but such characteristics carried no derogatory implications from his peers. The only qualities attributed to Ben which implied a criticism were being afraid and lacking a sense of humor—especially about himself.[26]

In the neighborhood around his home he had few friends. Ben was kept close to his family because he was needed to do chores and take care of the younger children. When there was time to play he got into a lot of quarrels and fights with the other children in the neighborhood. He wanted to be boss, carrying over the role he had at home with his younger brothers and sisters. He had one friend, Vernon, who lived near him and with whom he walked to school every day. But this friendship was rather casual and seemed to be based more on convenience than on any close, warm relationship.

Relations with teachers. His lack of social adequacy, if that is what his reported behavior in the early school years indicated, did not interfere with his academic success in school during the early years. When he was seven and a half years old and in the second grade, he was skipped a half

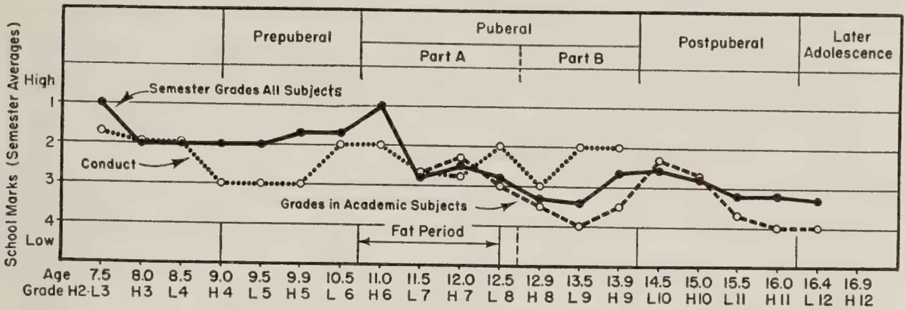


FIGURE 209. The curves of Ben's record in school start at the time he was skipped a semester in the elementary school. The downward trend of marks during the junior high school years was begun during his early adolescent fat period. Improvement in the last semester of the junior high school occurred when he entered a special class and continued in the tenth grade when he first began formal study of his family's native tongue. The final decline in the last semester of the senior high school was preliminary to his failure to graduate.

year, and his scholarship was "Excellent." The skipping of this grade automatically made him one of the youngest in his class during the remainder of his school life. Since he was actually one of the biggest boys in his class and among the brightest, it probably seemed a wise procedure to accelerate him in school. However, one wonders whether, if social adequacy had been taken into account and he had been kept with his original group, this would have made any difference in later school years. His grades immediately went down to an average of 2 and remained there until the beginning of the puberal period. (See Figure 209.) In deportment, he also showed a slump, which may indicate that his restlessness and talkativeness annoyed his teachers more than it did his classmates.

Summary. The picture we have of Ben during the prepuberal period is one of close identification with his family, of acceptance of their problems as his problems, of sharing in duties and responsibilities. His relation with his mother seems warm and sympathetic, but toward his father one glimpses an ambivalence of admiration and fear. There is evidence of real warmth toward his baby brother; toward his sick brother a mixture of concern and irritation; toward his older sister some competition and resentment. Although his early relations with classmates indicate some feeling of inadequacy, by the prepuberal period he seemed to be accepted and liked in school. He lacked the support of a close, intimate friendship and had difficulty in getting along with children in the neighborhood of his home.

In school he was doing well, though not excelling as he had done in earlier years.

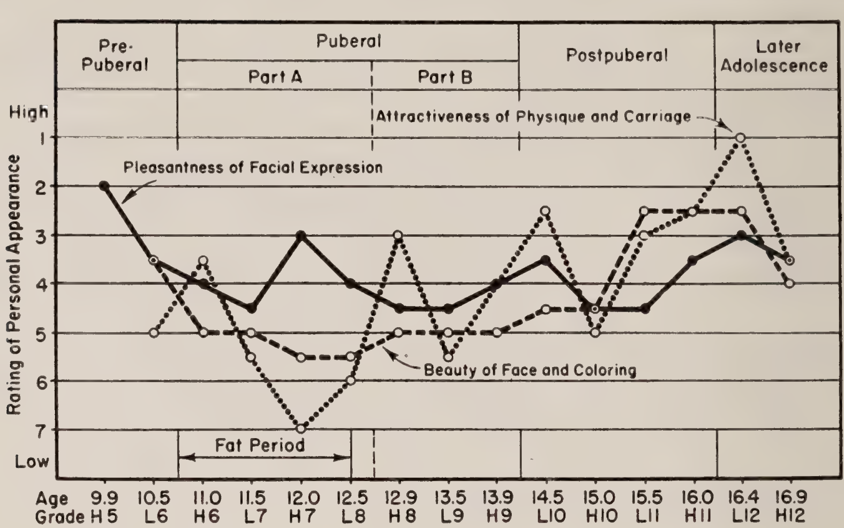


FIGURE 210. At each physical examination the doctors and assistant rated Ben on items of personal appearance. Note the low ratings on physique and face during his early adolescent fat period and the higher ratings as Ben became more mature.

THE PUBERAL PERIOD: **Part A**

Somatic development. The puberal period of development, which lasted three and a half years, can be divided into two parts. The first part includes the time from the onset of the accelerated growth in height and glans penis to the apex of height growth. Ben was between 11 and 12.7 years of age. It was for him a time of extreme fatness, slow development of genitalia, but of rapid changes in development of pubic hair. His legs were growing much more rapidly than his body, and his shoulder/hip width ratio was decreasing.

He showed evidence of eye strain and between ten and a half and eleven and a half years wore glasses.

Personal appearance. The net effect of these developmental changes can readily be seen in the photographs (Figure 195b). It is also evident in the ratings of personal appearance made by the physician and his assistant at the medical examinations.[27] (See Figure 210.) In attractiveness of physique and on masculinity-femininity the ratings went down from above average to almost the lowest on the scale. In ratings of "beauty of face and coloring" he made similar though not as dramatic changes.

Relations with family. While Ben was entering his puberal spurt, becoming a "fat boy," and making adjustments from elementary to junior high school, his family was undergoing great economic stress. Although his salary was slightly increased, Mr. Ruppert was continuously worried for fear he might lose his job. Mrs. Ruppert was pressed to make ends meet.

They bought no clothes; meat dropped from the diet; vacations, trips to see the maternal grandmother, and automobile riding in the country on Sundays were given up. There was no money for concerts or theaters, which they used to enjoy when they lived in the city. Even the movies had to be given up except occasionally when Lotta and Ben went with their mother. The radio remained as their big source of family pleasure. They had three of them, two of which had been made by Mr. Ruppert at home. They used them every evening, listening to dance music and symphonies.

In the fall, when Ben entered junior high school, his father was sent abroad on business. The children at home now called Ben "Daddy, Jr."—probably a recognition of his growing maturity and increasing responsibility in the family. Ben was not sure he liked all the implications of this appellative. He played most with his baby brother, Ferdinand, and indicated his pride in Ferdinand when he said, "Ferdinand isn't shy like Paul. He will go right up to a stranger." Later we find Ben on several occasions at the Institute playing a friendly and protective role with the young children in the nursery school. He complained about Margaret and Paul who he said were continually fighting. But his strongest antagonism was to his older sister. He complained that she wouldn't work or take care of the children and that she had a temper.

In general his family life was not satisfactory to him as reflected in the adjustment inventory (Figure 208). His counselor shortly after he entered junior high school saw this as a causal factor which affected other areas of his life. She noted on his record:

> This lack of social adjustment, added to difficulties at home, keeps him from doing his best work. He has a rich inner life and probably broods too much on the unsatisfactory elements of his school and home life.

The next spring, when Ben was in the high seventh grade, there was some relief in the family situation as Paul, the handicapped child, was finally entered in public school at ten years of age. He had previously been diagnosed by a physician as a glandular case. Now the school psychologist stated that "this was a feeble-minded boy whose behavior was perfectly conventional and who did not cause any trouble in the classroom." The next fall he was transferred to the atypical class. At that time Mr. Ruppert was out of work, and the family could not afford carfare for Paul but thought they would probably be able to pay it the following term.

There is a diary of activities which Ben kept during the first week of December when he was in the low eighth grade. He was still doing many home chores: taking care of his room, going to the store, doing dishes, caring for his brother, watering the lawn. Not all of these every day, but enough to keep him pretty busy. In addition, he sold magazines on one

day and had a weekly piano lesson. He checked doing the dishes and the piano lesson as chores he did *not* like. One evening, he stated, "I boxed with my Dad."

During these two years of rapid growth he indicated an increasing desire for independence from the family. He didn't like it because he couldn't go out without a "chaperone" at night. He was also very anxious to drive the family automobile but could not, of course, because of his age. Now, instead of wanting to go home after school and help his mother, he wanted to go to a friend's house, and later wanted to have friends at his home.

Relations with boys. There is a good deal of evidence that this was a difficult time for Ben in his relations with other boys. Before he entered

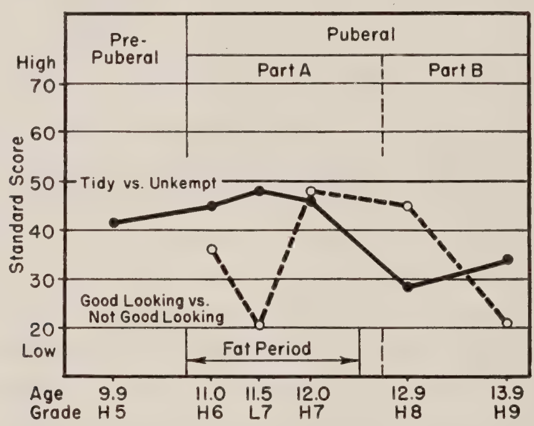


FIGURE 211. On the *Reputation test* which was given to the children in the study periodically, there was an opportunity for the children to express their opinions regarding the personal appearance of classmates. Ben was consistently rated below average in tidiness but during the puberal period this was not considered particularly undesirable for boys. It is difficult to explain the extremely low rating in looks when Ben was 13.9 years old except by the personal bias of a few people. There were no comments on Ben's appearance during the postpuberal period by his classmates.

junior high school his standing with his classmates was waning. No longer was he considered a leader or active in games, and he still lacked a sense of humor. They thought of him as somewhat childish, going with younger friends. He was judged as mildly restless, talkative, and seeking attention. They corroborated the opinion of adults that he was decidedly not good looking and somewhat untidy (Figure 211).

The next fall after he entered junior high school relations with boys got even worse. He said to his counselor:

There's always a fight when I play with boys in the neighborhood. That's why I stay home and help; anyway, I have to. Maybe I'll get a bicycle for it.

Yes, Vernon and I fight a lot, too. Sometimes I'd like to stay home from school because of all those fights with Vernon. The boys at school tease me, too. I don't mind a little, but it goes too far. What's more, they always choose me last in games.

He mentioned himself on one inventory as one who fights, but modified this somewhat on another when he stated that he was a moderate fighter but wished he could beat any other boy in a fight. It looks as if he had difficulty in facing the fact that he really did not meet up with the ideal behavior of his classmates, that he, too, had accepted as a self-image. He reported himself as liking to play games with boys, especially rough ones, and as daring and active in games. But his classmates did not agree with him.

During the peak of his fat period he considered himself unpopular. He was unhappy a good deal of the time because no one liked him. He said boys and girls played mean tricks on him often. He did not have much fun, but he would have liked to. This was the only time in the records when he looked back to early childhood as the time when he had the most fun.

Ben was unpopular with boys; he knew it and felt it deeply. He revealed his feelings in conferences with his counselor and on the social and adjustment inventories. He mentions himself more and his classmates mention him more on the inventories during this period than in any subsequent period. He lists Vernon as his best friend, but no one, not even Vernon, mentions Ben as best friend.

His counselor summed up the situation in this way:

Ben's chief difficulty seems to be social maladjustment. He is inclined to be on the defensive and to blame others for what goes wrong. He does not feel that he is liked, and he feels left out in sports.

Every six months, when Ben came to the Institute with several other boys for examination, he was observed and rated by several adults. These data give a vivid picture of Ben in his relations with a small group of other boys. The ratings of the adult observers are shown in Figures 212 and 213.[28] The general trend of these ratings is surprisingly similar. All the ratings on social attitudes and social behavior decline sharply during the first part of the puberal period when Ben was fat, and begin to rise slightly toward the close of the fat period. It is only at the beginning of the period that any of his ratings are much above average. There are some notable exceptions to this. *Popularity,* which was one of the elements in *sociability* (Figure 212), is only just above the average when Ben is eleven and never goes above again. The whole constellation which makes up *social prestige* is consistently below average during this fat period (Figures 212 and 213).

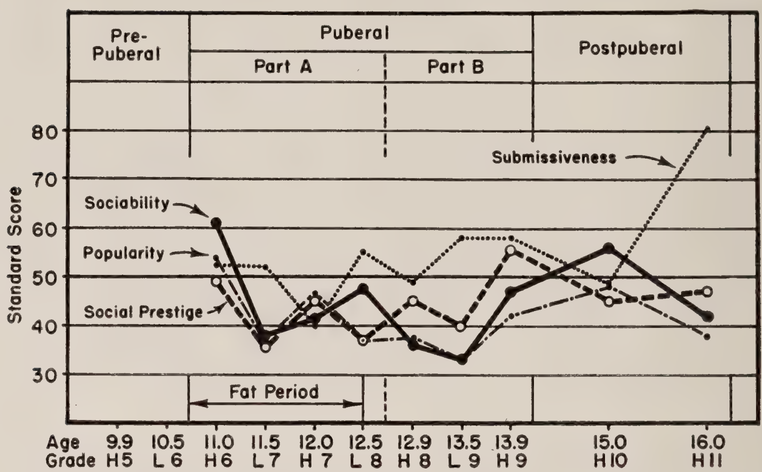


FIGURE 212. Adults rated Ben every six months when he was with five or six other boys in informal situations and at play. *Sociability* is made up of ratings on several items (social, enjoys games, good-natured, popular, and submissive). *Social Prestige* combines several items too (initiative, leader, marked effect on group). The items of *popularity* and *submissiveness* which are items included in *Sociability* are shown separately because of the interesting differences after the peak of the fat period.

Poise and the elements that go into this rating give another slant to the picture. (See Figure 213.) Although all of the curves go downward at the beginning of the fat period, the curve for *uninhibited* soon makes a sharp rise. In spite of Ben's lack of social assurance and confidence in games, he was not inhibited in his behavior when he was twelve. This aspect of his behavior was probably related to other elements which suggest a covering up of his basic needs rather than an expression of any social gains.

In spite of his lack of success in social relations with boys and his feelings of inadequacy and unhappiness during this phase of his development, he seems to have simulated a certain amount of emotional buoyancy (Figure 214). Except for that most hazardous time when he had just entered junior high school, the ratings on emotional buoyancy are all above average. This laughing, cheerful, seemingly relaxed exterior may have been the screen behind which Ben hid his real feelings.

One wonders also whether the high level of his expressive behavior (except for the time of junior high school entrance) may not have been somewhat compulsive. (See Figure 214.) His talkative, busy, eager manner may have been his ineffectual way of getting into things, trying to be a part of the group. This point of view is somewhat supported by his ratings on *nonattention-getting* which got correspondingly lower as the *expressiveness* curve went higher (Figure 214).

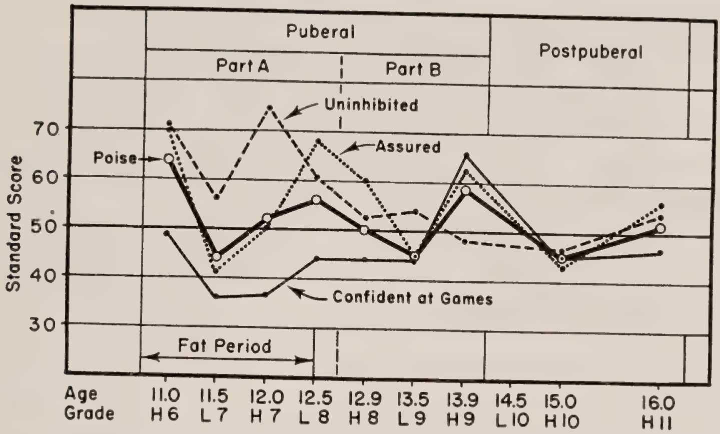


FIGURE 213. The rating by adults of Ben's *poise* in a small group of boys is made up of three items (assured, confident in games, and uninhibited). The discrepancy between the ratings on *confidence in games* and *uninhibited* during the first part of the puberal period is in direct contrast to the uniformity of these same ratings during the postpuberal period. It is probable that his uninhibited behavior during the fat period was a mask for his lack of social acceptance during this time.

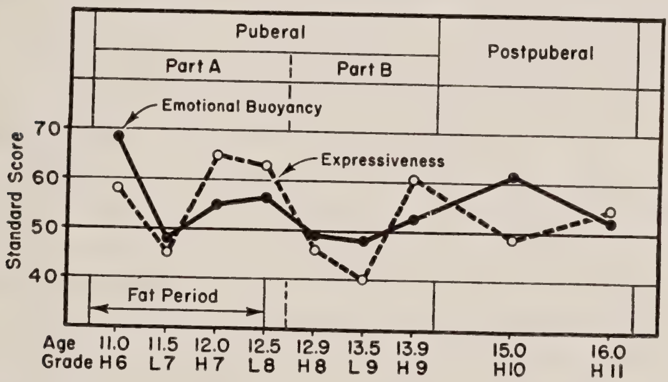


FIGURE 214. These curves show the general trend of adult ratings of Ben on *emotional buoyancy* (including laughing, cheerful, relaxed, carefree) and *expressiveness* (including eager, talkative, active, busy, peppy, animated face). The contrast between his outward expressiveness and his sociability (Figure 212) during the fat period should be noted.

In the fall, when he was in the low eighth grade and was just beginning to lose fat, his classmates gave him relatively few mentions on the Reputation test, and no extremely derogatory ones. He was considered slightly unpopular and below average in avoiding fights. He also was considered mildly childish, untidy, restless and talkative, but as one who avoided being the center of attention. He was not considered good looking.

He mentioned himself as being unpopular (as he did throughout his fat period), but he at the same time mentioned himself as having such desir-

able qualities as daring, active in games and fights. He agreed with his classmates that he was talkative but, in addition, mentioned himself as assured in the classroom. Vernon was again mentioned as his best friend.

That same fall, when he was 12.5 years of age and when he was definitely coming out of his fat period and assuming a masculine pattern of development, we find this observation at the Institute:

> Ben had an unusually good time today. Nobody picked on him. . . . He frequently has a bad time—boys "rag" him sometimes—but he has an irrepressible fund of energy, eagerness, etc.

However, even though relations seem to have been better between him and his companions, there is some indication that he still had difficulty in knowing how to play with boys. This observation was made in the Clubhouse yard:

> Came over with Loren. Asked for baseball to play with first, then went to get the football when possibility was suggested to him. The first time Loren tackled him and knocked the ball out of his hands, he said, "No fair pushing it out of my hands." They passed the ball back and forth, Ben passing it well, but catching it rarely. Loren commented on his not catching it, whereupon Ben said, "All right, try and catch this one. Let's see how good you are." He threw such a forceful one that Loren couldn't catch it.

At the end of the low eighth grade adult raters judged him to be decidedly unpopular with his classmates and lacking in leadership. Exceptions were the physical education teacher, who rated him average in popularity, and one observer at the Institute who rated him average in leadership. He was likewise rated low in self-assertiveness and in self-confidence with regard to social relations. His identification with the group was rated below average. His drive for attention was above average, and it was the only social characteristic that was above average. The discrepancy between his high drive for attention and his low popularity and leadership seemed to be of significance in later development. (These ratings will be found in Figures 215, 216, and 217.)

Relations with girls. Ben was beginning to be interested in girls during this first half of his puberal development, but when his interest started and how it was manifested we do not know. At the onset of the period, his mother said that he had no interest in girls and had a strong resistance to participating in social dancing. But by the time he was in the high seventh grade, two of his three wishes were to have more friends and to have girls as well as boys like him better.

The next fall a clubhouse was opened near the junior high school for the boys and girls in the study. Two months later Ben was playing football

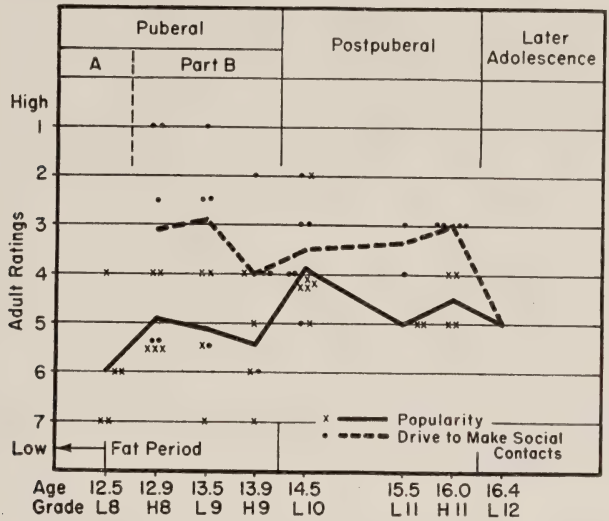


FIGURE 215. These ratings were made by adults at the Clubhouse and on excursions where both boys and girls were engaged in many different kinds of social activities. The dots and crosses which designate the ratings of different observers in different situations show the wide range in the evaluation of Ben's relations with other boys in mixed-sex situations. The line is the average of the ratings during each semester. The Clubhouse was closed by the time Ben was fifteen, which accounts for the decrease in the number of observations. The tendency for Ben's drive to make social contacts to fall gradually to the low level of his popularity is an outstanding characteristic of these curves.

with a boy in the yard of the Clubhouse, when the following observation was recorded:

> Barbara and Charlotte were watching the boys most of the time. They didn't pay any particular attention to the girls but noticed them, and, when called over by Charlotte, Ben clapped his hands in her face in response to some comment she made. She and Barbara got into the game a little toward the end.

These two girls were both mature at that time and obviously interested in boys. Barbara was attractive and hyperactive; Charlotte was just beginning to bloom. They were both pretty "boy crazy" and anxious for any contact with a boy.

At that time, as Ben was emerging from his fat period, he seemed to have an average interest in girls, and his drive for attention was above average. However, his popularity with both sexes was low. (See Figures 216 and 218.)

Relations with teachers in the school. It is interesting to note that during the first part of the puberal period Ben's grades at school were actually improving. This was the time when he was definitely growing fat, and also

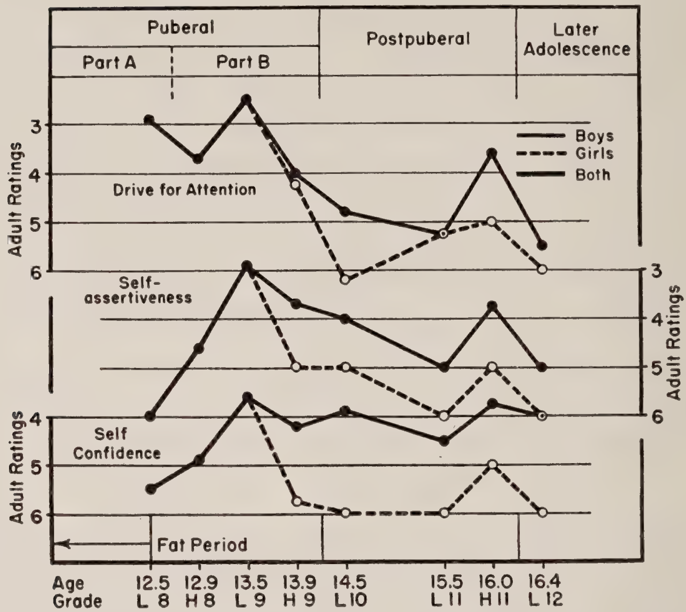


FIGURE 216. These three curves are of adult ratings of Ben on *drive for attention, self-assertiveness,* and *self-confidence,* as observed in social situations of boys and girls. The first year the ratings did not differentiate between Ben's behavior with boys and his behavior with girls. His drive for attention was above average in the middle of the puberal period but decreased rapidly in relation to both sexes. Self-assertion and self-confidence rose after his fat period to above average, but from that point he consistently had better relations with boys than with girls.

when his family were feeling the pinch of the depression economically. There are no descriptive records to help determine what part various possible factors may have played in bringing about this increased scholastic success. Ben may have just begun to get over the scholastic handicap often associated with skipping; he may have been compensating for his social inadequacies and his physical appearance; he may have been spurred on by his increased velocity in growth; he may have felt an increased obligation to succeed because of the family financial condition. On the other hand, if we had the records, his improvement might have been due to the wise guidance of a sympathetic teacher.

But at this time, when his school accomplishments were markedly successful, his feelings about school, as indicated on the Adjustment Inventory, were low (Figure 208). When he was at the peak of his fat period, he entered junior high school. That fall he was given an individual Binet and attained an I.Q. of 119, a mental age of 13 years, 7 months at the age of 11 years, 5 months. The summary states:

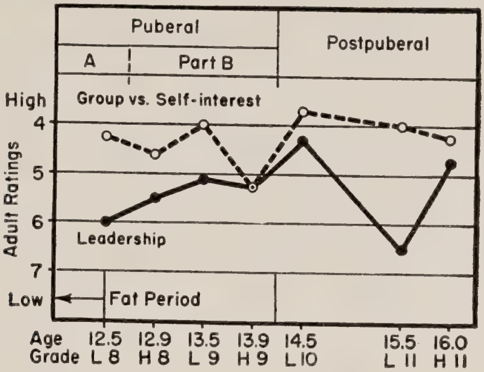


FIGURE 217. Ben's *interest in the group* and his *leadership* in mixed-sex groups as evaluated by adult observers are shown on this chart. The scale was from 1 to 7, in which 1 was high. Ben's ratings were low, but his ratings on leadership have a steady upward trend for two years following the end of his fat period.

His performance on the test was spotty. He would fall down on one part of a test, after he had done the other parts very well. His slips of attention he covered up by making it seem that he had not heard. He is systematic and resourceful. His reasoning on this test was excellent. He showed good common sense. He has a good vocabulary in spite of the fact that he speaks German at home. He misinterprets ordinary words because of this, but he knows how to use a good many difficult ones.

In spite of his mental ability, the decline in Ben's school work began in his first semester of junior high school. (See Figure 209.) In the high sixth he had stated that he felt assured in class, but this assurance had left him in the low seventh. It looks as if leaving a small elementary school, under the close supervision of one teacher, amid companions he had known for several years, and entering a large junior high school with several new teachers and many boys and girls whom he did not know may have been too great a hazard for Ben when he was at the peak of his fat period. It was at this time that Ben told his counselor that the boys at school teased him and chose him last in games. There is the possibility, of course, that increased competition in the junior high school also contributed somewhat to his decline in grades.

At the end of his first year in junior high school his grades were only slightly better than they had been the first semester. However, a report sent out to his parents by the Institute staff at that time lists the following as among Ben's six most outstanding characteristics: unusual intellectual curiosity, superior vocabulary and maturity in abstract thinking; and includes as additional characteristics unusual imagination, independence in thinking, and maturity in judgment. But the downward trend in school

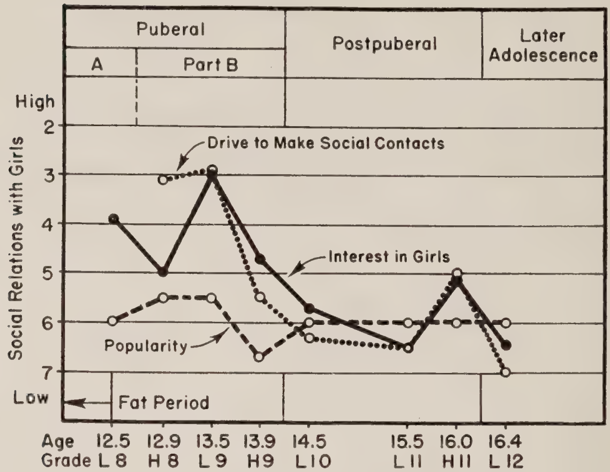


FIGURE 218. Ben's interest in, behavior toward, and acceptance by girls at the Clubhouse and in other social situations, as evaluated by adults, is shown on this chart. During the high eighth and low ninth grades he had a strong drive to make contacts with girls, a natural interest for boys at the apex of their puberal growth. But these drives soon decreased to the low level of his popularity, at least in his overtly expressed behavior.

grades continued the next fall, even though he was coming out of his fat period and showed improvement in certain social attitudes and behavior.

Summary. The first part of the puberal period brought many problems to Ben, some of which were centered around his own body growth and some around his increased urge for social recognition among his peers. A thick layer of subcutaneous tissue, wider hips, and longer legs combined to give him a fat, broad, short-waisted look which tempted the jibes of the boys. Never very skillful in games, his heavy body with its asynchronous growth made him even more awkward. The boys teased him and rejected him on the playground. Ben, who never had felt quite at ease with boys, lacked the self-assurance and the sense of humor which he needed to meet this situation. Outwardly, he responded by quarreling and fighting, but deep within him he was hurt and lonesome and unhappy.

Just at a time when he was becoming increasingly conscious of himself and his masculine goals, he was confronted with the fact that he was far from being either athletic, courageous, or a leader. These problems of social recognition and acceptance came when Ben needed the support of a happy school life to compensate for the economic difficulties his family were facing. His close identification with his mother and brothers and sisters put a heavy emotional load on this sensitive, intelligent boy.

The change from a small elementary school to a relatively large junior high school intensified the difficulty of the social situation which Ben had

to meet. His decreasing success in schoolwork was the academic evidence of his complex deep-seated unhappiness.

THE PUBERAL PERIOD: Part B

Somatic development. The second part of the puberal period, when Ben was between 12.7 years and 14.2 years of age, had very different developmental characteristics from the first part. Height was still increasing rapidly, but the rate of growth was decelerating from the apex. This was the time of greatest development in length of stem and in breadth of shoulders. His weight increased but it was due to muscle growth rather than fat. He had lost the heavy layers of subcutaneous tissue during the previous year. During this part of the puberal period he made his greatest gains in strength. But in spite of this, his bulk led one to expect much greater relative strength than he ever achieved. He reached maturity in glans penis growth and pubic hair development during this time. When the puberal period was completed at 14.2 years of age, Ben had developed into a fine-looking specimen of masculinity. (See Figure 195b.) His health record was good except for an attack of mumps when he was thirteen years old.

Family relations. The general situation in the family began to improve as economic conditions slowly got better. By the time Ben was ready to graduate from junior high school his father had gone back to work and was again sent abroad on business.

But Ben was growing up, and he was irked because he couldn't go places without first getting permission from his parents, and he continued to want to stay out at night as late as he pleased and to choose his own clothes. He no longer liked to go home after school to help his mother but preferred to go to a friend's house.

Toward the end of the puberal period, when he was in the last semester of junior high school, he no longer wished that his parents had more time to spend with him, and he left his mother and brothers and sisters out of the picture in his plans for living on a desert island. Instead, he practically thought of taking a doctor, and later a friend.

At the time of junior high school graduation, his counselor wrote:

> They have a large family and all have felt the strain due to precarious financial conditions. The mother has attacks of asthma, and Ben has had to help her a good deal with housework and taking care of the younger children. Conditions became acute when Ben was in the eighth grade but have improved a good deal this last year.

Relations with boys. In his relations with boys there was no sudden or dramatic change, but, as he developed in strength and masculinity, relations were decidedly better than they had been during the peak of his fat

period. The ratings of social behavior and attitudes made with the small group of boys at the Institute show in many instances a rhythmic development, with a decline during the high eighth and low ninth grades, followed by a rise during the last semester of junior high school. This was the case with all the elements of *sociability* except submissiveness. In that trait he made a rather steady increase from his lowest rating at the peak of his fat period (Figure 212). *Social poise* follows the same general pattern as does *expressiveness* (Figures 213 and 214). After the seemingly compulsive, active, talkative period toward the close of his fat period, Ben gradually subsided to a below-average rating until the high ninth grade. At that time he again became very expressive, and his score on *attention-getting* increased (Figure 213). This seemed a more integrated and less compulsive expression, for his social prestige was rising (Figure 212), and he was definitely cheerful.

We have also available for the latter half of the puberal period observations and ratings of his social behavior in mixed-sex groups. These observations and ratings were usually made at the Clubhouse, but there are a few from the social dancing class. There seem to be some differences in Ben's relations with boys in these situations where girls are present.

In these situations there was in general an upswing in his ratings in social behavior with boys. In the low ninth grade he was above average in drive for social contacts, drive for attention, self-assertion, and poise.

In spite of this evident expression of social drive for contacts with boys, and his outward manifestation of self-confidence, he was still low in popularity and leadership. This discrepancy between social drive and social success became less in the high ninth grade, partly owing to the fact that "drive" had come down to an average rating (Figures 215, 216, and 217).

It would seem that in certain situations Ben was somehow gradually working out more satisfactory relations with boys as he was acquiring masculinity and strength. As he became less unpopular, his drive for social contacts lessened, and his bids for attention decreased. However, one must not assume that his social adjustments were adequate or secure, even with this improvement.

In the high eighth grade he was seen by adults observing in various classes as a boy who was "popular with some, but excluded or ignored by others." The question naturally arises—with whom was he popular? He mentioned on the Reputation test four boys as being his best friends: Vernon, the boy whom he had mentioned each time and continued to mention to the end, and in addition Gus, Eric, and Alden. This last boy was the only one who mentioned Ben as best friend. He was an outstanding, popular boy with generous social attitudes.

On the day at the Institute just before his thirteenth birthday Ben was with seven other boys, all of whom were older than he (from .1 year to 1.6 years) and six of whom were less mature physically. Only one boy, .6 year older, was as mature as Ben. Excerpts from the comments of observers substantiate the general description that he could get along with some, although excluded by others:

> Ben is not very effective with the group, but he has a certain self-expressiveness which may be part of an attention-getting device. . . . Gets on well with Dwight, his partner.

Another observer states:

> Although he made no attempt to join the other group, he was very much at ease, got the basketball, and began playing with Dwight. He was the obvious leader in relation to Dwight.[29]

In spite of the fact that he listed certain boys as his best friends, adults believed him to be usually "indifferent to the individuality" of his classmates and only rarely to show any preference.

Sometimes he exhibited a strong drive to make social contacts, "takes every opportunity for social contact" as in physical education dancing class, "hangs around groups and tries to become part of them"; but at other times, in class, he directed "no attention or talk to others." However, except on one occasion, the observers thought he was self-conscious and aware of his audience, although the degree of manifestation in gestures and talking varied.

He also seemed self-conscious and shy except with friends or in accustomed situations, when he was "fairly assured." However, although vulnerable and not usually successful in protecting himself from social hurts, he could be assertive in protecting his property, as shown in this observation of him on the day at the Institute:

> Bryce picked up Ben's camera from shelf and started to manipulate it. Ben reached over, pulled it out of Bryce's hands, and firmly set it down on shelf and walked away, keeping a belligerent eye on Bryce. Latter did not touch it again.[30]

At this time Bryce had a great deal of prestige among the boys. He was considered a "tough guy," and very few of the boys would have stood up to him. Bryce seemed somewhat amused by this episode and walked off with an air of surprised condescension.

It was at the close of the eighth grade that his classmates gave him the highest ratings (just above the midpoint of the scale) in leadership, daring and "fights"—the constellation which seems to carry the most prestige at that age. Active in games, which belongs in this group, was slightly below

the mid-point. They rated him above the mid-point in restlessness, talkativeness, attention getting, but did not judge him extreme on these characteristics. His sense of humor as to jokes and himself was positive, and they considered him happy. In general, this was the time when they gave him the most mentions on desirable social qualities.

The picture of his relations during the next semester is somewhat similar. He hung around groups, was accepted by a few, was rebuffed by others. Convenience still seemed to determine with whom he played. He seemed to assert himself somewhat more actively than before. Some excerpts from the observations at the Institute are revealing:

> Ben went through the motions of being part of the group today, but frequently met with rebuff. On the swing others complained of his performance, and in play with phonograph he was pushed away, told he was spoiling the game, etc. He was left in partner choosing to go with Horace.

An element of teasing which was not well accepted by his classmates seems to have entered into his behavior.

> Teased the others when they were experimenting with the victrola. His experimenting was not tolerated—jumped on by three others, Harry Huggins, Lanny, and Dwight.

However, other boys indulged in much sharper teasing but "got by with it" because of their popularity.

During this semester he went to the Clubhouse 76 times (a more frequent attendance than at any other time). He came at noon, the sixth period, and after school. The *quantity* of his social contacts seems to have increased as well as his leadership, poise, and assertiveness. (See Figures 216 and 217.) A large proportion of his time at the Clubhouse was spent in watching, wandering, fooling around. But he also began to play football in the Clubhouse yard with a small group of boys. All of these boys were chronologically older than Ben (from .4 year to 1.2 years). Two of the older boys, Clayton and Herbert, were more physically mature and had large bony frames. Both of them were boys' boys and somewhat nonverbal. Another older boy, Jerome, was at about the same position in development as Ben, the same in height but not as muscular nor as strong. Ed, the boy who was recorded most often as Ben's companion at the Clubhouse during the next spring, was .7 year older and at about the same developmental level. He was about average in size, but much smaller in bulk than Ben. He was a quiet, mild boy with a meager economic background which showed in his poor clothes and unkempt appearance. Two little boys, Paul and Carter, sexually undeveloped but with good physique for their stage of development, and one fat boy, Rod, whose development was sex-inap-

propriate, made up the list of those who, from time to time during the late fall and early spring, played football in the yard. None of these boys was socially mature or popular with the more popular boys or the dancing girls. This was probably why Ben was accepted by them and why he was able to continue to have relations with them from time to time.

Phrases from an observation at the Clubhouse describe him:

> Buzzed around rather aimlessly from one room to another. . . . Follows Rod around. . . . Popular with Rod, who is not popular. They were together all the time. . . . Influences Rod a little. . . .

In addition, he was continually bidding for attention by making others aware of his presence by talking.

Beginning sometime in the spring of the last semester of junior high school, there is evidence of a change in his behavior—a tendency toward settling down, less seeking of attention, and more grown-up type of behavior.

> Is increasingly social. At end of games he was at bat, refused to quit, and the others could not get him out. Very confident.
>
> Seems somewhat more adjusted . . . was most talkative and expressive in this group.

His attendance at the Clubhouse decreased to about half what it had been the previous semester; he came only at noontime now. This was in line with the general trend in clubhouse attendance at this time. However, it was the older group who graduated to senior high school who in general no longer came to the Clubhouse which was several blocks away. The group still in junior high (of which Ben was one) continued to come, though activities changed. Dancing and party activities declined, and card playing among boys increased.[31]

About half of the time that Ben spent at the Clubhouse he was wandering, watching, fooling around. The activities of strenuous games continued in basketball, especially with Ed. He learned to play monopoly and for a couple of weeks in May played often with Elmer Day and Ed; sometimes with Jerome, George, Chuck Reed, and Walter Goodrich.[32] He was still not accepted by most of the boys:

> His company is avoided by the popular boys at the Clubhouse. . . . Arouses negative reactions through his critical attitudes . . . not a fringer but disliked for his mood and manner.

His classmates increasingly ignored him on the Guess Who test. They disagreed about his having older friends, though the final score was a positive one.[33] He was given a low rating on tidiness at a time when the boys' standard for neatness and cleanliness was rising. He was not con-

sidered happy and was lacking in humor regarding jokes. He only mentioned himself twice—as one who fights (as previously) and as one who is embarrassed in class. The increasing lack of mention by his classmates may be related to the decrease in overt signs of attention getting, drive, and assertion of Ben as reported by adults, and it may also be related to the active, social behavior of the leaders in the upper grade group who were the focus of attention of most of those who attended the Clubhouse at this period.

He mentioned six boys as his best friends (the largest number of any year) and three boys mentioned him as best friend (the only time this ever occurred). He was mentioned by Harold Weston, Ed, and Dwight, and he mentioned the latter two. He continued to mention Vernon, who never mentioned him. The friendship between Dwight and Ben is interesting. Dwight was .7 year older than Ben but about a year behind him in physical maturing. He had been through a fat period between eleven and thirteen years, rather similar to Ben's fat period, since it was not a sex-inappropriate period. Dwight was developing rapidly, was friendly though not effusive, alert and rather well liked by both boys and girls.[34]

At the end of junior high school, we find this statement in the counselor's summary of Ben:

> . . . The latter part of the semester has seen quite an improvement in his adjustment. . . . He sought the company of boys who were likewise not popular and found some companionship. Latterly, he has become more generally acceptable to the other boys and even had quite a good time with other nondancers at the two graduation parties. . . .

Relations with girls. As Ben developed in the second part of the puberal period, he showed the to-be-expected desire for more associations with girls. During the high eighth grade there was, in general, an increase in his interest and drive for contacts with girls. This interest seemed to be indirect. He was self-conscious in their presence, and his drive for attention seemed to be increased. Popularity was low (practically the same as in the low eighth grade). He was frequently ignored, and in dancing class at school was "never asked to dance, though he will be accepted as a partner if he asks."

There are thirty-five records of attendance at the Clubhouse, but only one mention of any activity with a girl. This was a game of badminton with Natalie, who was an athletic, slow developing girl. There was one episode which is worth reporting.

> At a girl's surprise party at the Clubhouse the girls were playing Truth and Consequences. The question was "What boy at Junior High or in H8–1 do you

like best?" Lucia hedged the longest—saying she'd rather have a boy outside school. When they wouldn't let her, she said, "Ben."

It is interesting to note that Lucia was one of the youngest girls in the study. She had none of either the aggressive drive toward boys or the sophisticated behavior of the more mature. She was very bright, and in the same section with Ben at school. The observer suggested that there was a possibility that she said "Ben" because she was sure everyone would know that she was only jesting.

In the low ninth grade he reached his highest point in interest, drive, self-assertiveness, and poise in relations with girls (Figures 216 and 218). However, although he had "a good deal of interest," he was "without ease of expression." He was still self-conscious, giving "no apparent response to the individuality of girls," although seeming to be an "interested observer of all girls present." One direct expression of this interest, which was reported, was an instance of teasing:

> Busy mainly in teasing Rose Field—she seemed to like it but became frantic and appealed to Miss McC. Ben was unmoved, merely turning to some other activity.

An observation which seems rather typical of boys' behavior during a period when they are interested in girls but have few if any social techniques was made of Ben with a group of boys at the Clubhouse one noon:

> They stood huddled near the door, not venturing to mix with the other boys or girls present. No boys were dancing, although Lester Castle was getting girls' attention and waiting upon them, along with Alex and Carson. One of the former group pushed Bruce on the couch with Margaret, who paid no attention. Bruce blushed, was embarrassed, covered with confusion. Then they all went outside and horsed around noisily, hazing one another—perhaps still affected by the presence of girls just inside the house, but keeping their distance and not making any further moves toward them.

From that time on, all curves describing his relations with girls take a distinct downward trend. He continued to express his interest in girls, however, in his talk to adults. His counselor stated when he was about fourteen years old, "His talk of girls indicates marked interest but no technique."

Two comments describing his behavior during dancing class may indicate the time when this change in his outward manifestation of interest began to take place and give some suggestions as to the underlying causes:

> Asked if I couldn't send for him and get him out of dancing. Had preferred not to be taken out of that class a couple of weeks ago. He tried to dance this day, and got along fairly well until they were free to use whichever steps they

wanted to. Then he was lost, and came over with his partner to lament the situation.

Was trying to do what was expected of him, but he felt sorry for girls who had to dance with him. At the same time, he was too anxious to learn and too interested in the activity to try to escape. Made disparaging remarks about himself, and earlier about girls (especially the younger ones in the class). Welcomed adult sitting between him and girl. Said so. Then when he had enough dancing with girl, he brought her over to adult, while he complained about his own dancing (April, 1936).

The second comment was made a month later:

Blustering, arrogant, critical attitude at times—referred to girls sitting out in social dancing class as "freaks". . . . Antagonistic to girls—teasing and molesting as the form of response which he is most capable of expressing.

Not interested in dancing—escaped to the side lines with Roscoe when opportunity offered, and pretended to be talking to me. At Clubhouse seems to avoid contacts with girls, partly because he is not interested in them as individuals, but perhaps mostly because he is so unattractive to them. Devoid of sex appeal (May, 1936).

During two weeks just before graduation from junior high school, Ben played monopoly at the Clubhouse with a group including girls five times (Eileen five times, Ethel four times). Eileen was one of the younger girls in the group and also quite immature developmentally. She and two or three friends had regularly eaten lunch together in the kitchen of the Clubhouse, away from the active social groups. However, Eileen was probably more interested in the social activities than her other friends. Eileen was not attractive, a slight girl from a family of lower economic status. She also was in the same grade at school with Ben. Ethel was an immature, feminine type of girl who was liked by the immature boys throughout the period of the Study. She was somewhat motherly toward these socially immature boys; they felt at ease with her and used her in their first awkward experimenting in heterosexual social relations.

About that time, Ben again indicated that two of his three wishes were for more friends and to be liked better by girls as well as boys.

Relations with teachers in school. Ben's school grades do not take an upward trend until the close of the puberal period. In the final semester of junior high school he was put in a special class arranged for children who were not getting along well in regular classes. This group, known as the "Junior Explorers," was under the direction of a young man with many enthusiasms and with a real understanding of boys and girls during the puberal growth period. This may account for the fact that his grades take an upward trend. It is important to recall that during his final semester in

junior high school he made his best relations with boys, and even began contacts with girls in the Clubhouse.

Three years after he graduated from junior high school, one of his former teachers remembered him as "well meaning, average intelligence, absent often, very forgetful, likable, futile." Another described him as "noisy, intelligent, good student." The vice-principal said that he was "oversized, fat, awkward, well adjusted considering his physical make-up." His advisor, in her report made following Ben's graduation from junior high school, summed up the situation thus:

> Ben has never been able to use his very good intelligence anywhere nearly up to capacity. Any work requiring concentration or consistent effort has been poor. He had a good deal of trouble with his eyes and keeping supplied with glasses for a while, but this was not the main reason for his poor work. The strain at home contributed no doubt, but his very poor social adjustment at school bothered him so much that he couldn't keep his mind on his work.

Summary. If human beings could leave their pasts behind them this might have been a very happy period for Ben. The fat period was over, and this boy was rapidly becoming a man. His body was well knit, big, fairly strong, and masculine at the unusually precocious age of fourteen years.

But Ben carried the scars of his past experiences. He loved football and active games, but he wasn't very skillful. The discrepancy between goals and achievement made him irritable and petty in play. He just wasn't a good sport; he couldn't take it. His body had outgrown his social development, and often he seemed babyish—a blusterer and a whiner. His strong social drives and his persistent interest in football won for him a few friends among the younger and less popular boys. He usually found a small group who would accept him, if not as a leader at least as a participant in their activities. But one has the feeling that Ben gained little genuine satisfaction from his improved status with boys because he still was far from achieving the role he had envisaged for himself.

The rapid maturing of bodily functions spurred Ben to an active interest in girls. One would expect that a boy so physically well developed and masculine at fourteen would be pursued by girls in the eighth and ninth grades. That he was spurned instead of pursued needs some explanation. Part of the explanation lies in the fact that although Ben was physically mature, socially he was immature. When around girls he acted more like the silly self-conscious boys who were just entering the puberal period than like the few "sophisticated" mature boys in the eighth and ninth grades. In addition, he was still unkempt in his appearance at a time when girls were demanding careful grooming for an acceptable boy. Somehow he couldn't learn to dance, and his own sensitivity made him too embarrassed

to practice at a girl's expense. But probably Ben's greatest handicap in achieving any popularity with girls was his own lack of faith in himself, his own feeling of inadequacy in social situations which was based on the accumulated hurts of many years.

His family situation was better economically, and tensions were released somewhat. But they lived in the same old dilapidated house when Ben wanted to have his friends at his home and to give parties. Even though he was yearning for some independence, emotional ties with family were still strong, and he carried his home chores daily after school and on Saturdays, while his classmates danced or teased or played ball at the Clubhouse.

His record at school seemed to mirror his inner self. He could not break through his feelings of social inadequacy and mobilize his intellectual abilities. The upward trend in his grades as he neared graduation from junior high school perhaps gives a hint of what an understanding teacher and a few friends meant to Ben. But years after, his basic reputation lingered in the minds of his teachers—likable, well meaning, futile.

THE POSTPUBERAL PERIOD

Somatic development. Because Ben was such an early developer, records are available for two and a half years after the close of the puberal period. This takes him through the postpuberal period into late adolescence. He gained very little more in height (1.3 inches), most of it in stem length. But he continued to make marked growth in shoulder breadth, muscle tissue, strength, and weight. His increase in weight was largely due to increased muscles. It was at this time that he completed the final stage in pubic hair development. He reached maturity in testes development at 15 years and skeletal maturity at 16.4 years.

Health. Although the regular medical examinations were negative, Ben reported many colds and headaches during this period. He was absent from school seventeen times during one semester (H10) which he attributed mainly to headaches and colds. He had acne for a year (15.5 years to 16.4 years) at about the same time when he began to report headaches to the examining physician. Toward the close of the period he had a severe bruising of his pelvis while playing football.

Personal appearance. In general, adults considered him above average in appearance, rating him higher than at any previous period. Except for one rating, the doctors rated him high in masculinity and attractive physique. At the Clubhouse the adults still disagreed widely regarding his appearance. His classmates made no mention of him. But there was rather general agreement among adults that his face and coloring were attractive.

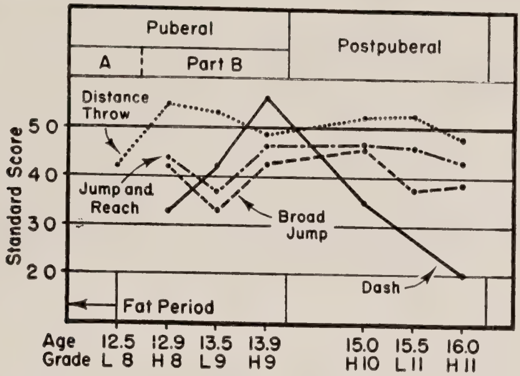


FIGURE 219. Ben's scores on various gross motor ability tests are shown in relation to the group average (standard score of 50). In spite of Ben's precociousness in physical growth, he was below average on most items of motor ability when compared with his classmates of the same chronological age in junior and senior high school.

Physical efficiency. In spite of the fact that Ben made marked increases in strength as measured by the dynamometer tests, his relation to the group in the gross motor activities remained about the same (Figure 219). Only in the distance throw did he even reach the average among boys of the same chronological age, most of whom were less mature than he was. The ratings of adults when he was with a small group of boys at the Institute support this; his skill in games was consistently below the average (Figure 220).

Relations with family. The economic hazards of the family were lessened by the time Ben began his final adolescent growth, but the family did not reach its old financial security. They still lived in the dilapidated house on the edge of a commercial district.

Ben carried a heavy load of home responsibilities and in addition earned money by jobs outside of the home. When he was fourteen and a half he was earning four dollars a week working in a store after school and selling papers. For a year (during the eleventh grade) he worked Saturday mornings at the school. Such jobs were always given to boys who really needed the money.

At home Ben's responsibilities varied somewhat in relation to the amount of work he carried outside the home. When he had the job in the store, he carried about four hours' work a week at home—caring for his room, doing dishes, cleaning windows, and washing and ironing his own shirts. The next semester (high tenth grade) he had no job but spent fourteen hours a week in home duties. When he had the school job he spent between five and ten hours a week doing home chores, which extended to include

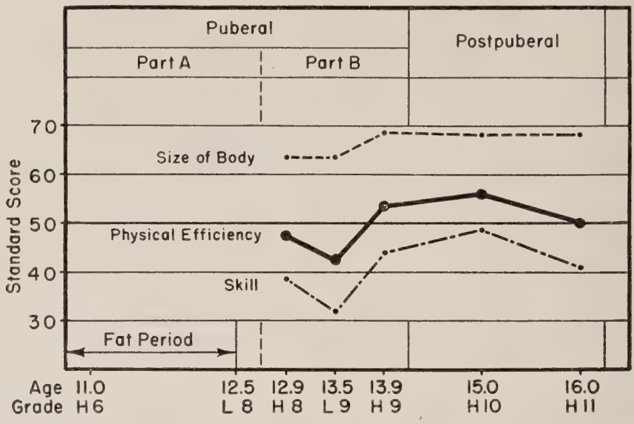


FIGURE 220. *Physical efficiency,* as rated by adult observers, included *size of body, skill, masculature,* and *enjoyment of physical activities.* The latter two were omitted from the chart since they closely followed the average rating. The discrepancy is wide between the size of Ben's body in relation to other boys of the same age on the one hand and his relative skill in physical activities on the other.

cleaning the living room, fireplace and yard, and gardening. When he was sixteen he learned to drive the family automobile, and so added going to the market, cleaning the car, and driving the family about to his other chores.

Part of Ben's heavy responsibilities at home were due to his mother's ill health. She had recurring spells of asthma which seemed definitely related to her own emotional concerns. Part of these were financial, but there were other things, too. When Ben entered senior high, Mrs. Ruppert said that she was concerned about the father's very strict discipline with the children. She did not mind his being strict with her because she loved him and could understand, but she did mind for the children—especially for Lotta who was nearly sixteen years old. This may have been one of the reasons why Ben said that same fall, "My mother's health is better; she hasn't had asthma since my father left for Europe."

In addition there was Paul who still was somewhat of a burden. His difficulties were finally diagnosed as cerebral palsy, and an orthopedic operation was performed. He stayed at home after this, and was given home instruction by the public schools.

But somehow Ben was beginning to feel better about his family. When he was sixteen he spoke of them with genuine pride, telling the art teacher about the background of his parents, their education, and their life in South America. His responses on the Adjustment Inventory, though still unadjusted, began to take an upward swing, and when he was in the high eleventh grade were less maladjusted than at any time during the study.

He felt very strongly during the first two years of high school that his parents treated him too much like a little child and did not let him make decisions for himself. Staying out late at night and asking permission to go places was still an issue during the tenth grade, but these and issues regarding clothes and chaperones had been resolved by the time he was sixteen.

When Ben was in the low twelfth, his mother was quite ill with asthma, and Paul was again operated on at the hospital. Ben "seemed worried about his mother." He was out of school altogether forty-six days, but only five of his official explanations could be interpreted as related to the family responsibilities. However, his counselor stated, "He was out of school irregularly for a while because there was no one else to drive his mother and brother down to the doctor." Later she noted again, "Has had many absences which he says are due to having to take his mother and brother to the doctor's office. No one else at home can drive." At that time his older sister was at home, and he reported in November and December that he did not have to do housework any more. However, excerpts from a week-end diary which he kept just before he was seventeen years old indicate that the family still depended upon him for many services, at least on week ends:

Friday: When I finally got home Friday I felt justified in taking an aspirin and then go upstairs and lay down, but what happens the minute I open the door, my mother calls out, "Is that you, Ben?" . . . My mother sends me to the store in the car, as I am the only one who can drive the car when my father is at his office. I am usually delegated to do the errands.

After dinner I fed my dog. . . .

Saturday, 12:50 After much tugging and shaking I was awakened by my elder sister who informs me that I have to scrub the kitchen floor, wash my dog, and wax the front room floor, also the little item of greasing and cleaning the car. What a day this is going to be!

Sunday: My sister wakes me at the unheard of hour of 5:30 A.M., asking me to take her to 6:00 mass in the car. I just turn around and say, "All right, all right, just a minute more in bed." Well, we finally went to 12:15 noon mass. . . . After returning home from mass we had lunch. . . . Then I took my two brothers and two sisters to the show in the car and left them. . . .

In addition to feeling somewhat put-upon by the demands of his older sister for housework and chauffeuring, Ben seemed also to feel the usual adolescent's annoyance with his younger brothers, even when one of them was Ferdinand, whom he had so adored as a baby:

After dinner I fed my dog and sat down to listen to the radio in peace—well, I listened but not in peace. My two younger brothers started to play; that is, they said they were playing; it sounded more like a couple of monkeys

fighting. . . . Can you imagine two healthy kids yelling their heads off while you were suffering from a headache . . . so I rambled off to bed.

The same week end he noted

After dinner my Dad and I went to the show. We got home about 12:20, had something to eat, and went to bed about 1:00 A.M. Monday.

The final description that we have of Ben and his family carries with it much more hope. It was given by him to his counselor the fall after he left high school when he came in to see about the possibility of making up the points he needed for graduation. He had dropped out of school the preceding January, lacking two points for graduation. In April he had secured a job in the city and had been working there ever since. He said that he did not need to work now as his father's business was much better. Paul was going to school and was rapidly catching up with what he had missed before his operation. Ben added, "Although he is no genius, his brain is all right now." His mother, however, had "just had another attack of asthma." But what was concerning him most was the house they lived in, of which Lotta had been ashamed for so many years. He said:

In case you want to know, we are still going to live in that old flat. I had hoped that we could move, but it seems that we are not going to. As soon as my sister and I get good jobs we are all going to pitch in and buy a home for the family up in the hills. . . .

Relations with boys. In the first months of the postpuberal period we find a further development of the trends in behavior which had begun to emerge the previous spring: decreasing aggression and increasing acceptance and popularity with a small group of boys. (See Figures 212, 213, 215, 216, and 217.) In addition, there seems to be an emergence of a certain reserve in social relations with boys, and some slight indication of an increase in critical attitude which was hinted at the previous spring.

His increase in acceptance by a small group is indicated in the following observations at the Institute:

With this group some stimulus value. This would not be true in most groups (Gus, Eric, Roger, Gordon, Carter).[35]

He was quite expressive and talkative. Played football with Gus as a partner most of the period. . . .[36]

Submerged in group—though accepted readily in touch football game, in which he plays with *some* facility.

He seemed to be somewhat more discriminating in his social contacts:

Makes a few social contacts—and then only with boys whom he happens to find stimulating temperamentally and intellectually. Last year Ben hung onto Ed, and now it is Owen Solano.

At this time the Clubhouse had been moved to a building across the street from the senior high school, where Ben was now in the high tenth grade. There were no facilities for outdoor play. Ben visited at the Clubhouse 51 times during that fall. He still did some wandering, watching, and fooling around but spent most of his time playing cards and ping-pong, talking, and watching dancing. His constant companions were Wayne and Owen Solano. Several other boys are mentioned in the records, but Carey Wise and Rollo Brown are the only names that occur more than once. Wayne was a year older than Ben but not quite as mature physically. He was not popular at the Clubhouse—a boy with a belligerent appearance, described as being close-mouthed and suspicious of the world and adults.

The element of reserve noted in Ben's behavior seems related to this increasing discrimination in the selection of companions and also to an expressed critical attitude toward those with whom he doesn't associate. The observations of four adults at the Clubhouse bring this out rather clearly:

> Rather standoffish and very critical of anything bordering on dullness on the part of his associates. Not very socially inclined. . . . His attitude is marked by a kind of severity and soberness.

> Poise—Has done unusually well in this respect this semester. He is very quiet this semester—no loud talking, no drive for attention at all.

> Friendly enough but very reserved. Likes to join in game but is almost unnoticeable. . . . Knew more about playing poker than the others, but let them play their way, offering no suggestions.

> Says very little, though was kidded a little when he first approached the group—took it good-naturedly, but fairly quietly . . . reserved behavior . . . definitely submerged in group . . . relaxed though not poised particularly—unconcerned. . . .

In the high tenth grade there were definite evidences that he was improving in his relations with boys and in the satisfactions he was finding with them. This can be seen to some extent in the ratings on sociability and cheerfulness (Figures 212 and 214), but it is especially evident in the observations of three different observers at the Institute when he was just past fifteen years of age:

> It seems to me that Ben showed signs of coming along very well. He persisted in playing baseball with Arthur and Larry, the more skilled group. While he didn't distinguish himself at bat, he was accepted by the other players and continued to play during the whole noon hour.

> He seems quite well adjusted. Was well poised. Took active part in games. He and Arthur came after balls at beginning of period, brought in bat, and

put it away at end of game. Seemed to have as much authority as anyone of the others. Played in the group of Arthur, Sam, and Larry. . . . Seemed to have a very good time.

Very little to contribute to the lunch conversation but seemed good-natured and a natural, easy member of the active groups after lunch (e.g., basketball with Arthur, football and baseball with Sam and Larry). Not eagerly sought by the others—once he was playing basketball alone—but an accepted member of the group.

The three boys with whom Ben played in the yard were all mature, well-developed boys, and Ben's success in getting along with these boys indicated a continuing growth in ability to get along and be accepted by the leaders among his peers. It is significant also that although one of the least popular boys, John Saunders, was also present, there is no mention of him on Ben's record.[37]

In the Reputation test, however, which was made during the same month as the Institute observations, Ben was scarcely mentioned by his classmates. Somehow, in the large high school of two thousand students, Ben was not of particular importance to his old classmates. He was mentioned as one who is slightly unpopular, talkative, and as one who fights. He mentioned himself six times in contrast to two times the year before. He considered himself as grown up, active in games, one who fights, but one who is shy with adults, embarrassed in class, and unfriendly.

No one listed him as his best friend in contrast to three classmates who mentioned him the year before. But Ben listed five boys as his best friends: Vernon (as usual), Gus, Otto, and two out of study boys. Gus was about a year older than Ben, but at about the same level of physiological maturity. He was, however, not as masculine or strong in build as Ben, though about the same height. He had wide hips, and when he was younger had been feminine in manner, acting more like a girl than a boy in his polite, considerate way with adults.

One wishes at this period that records were available on Ben's relations with boys on the school playground and during the physical education period. Some light might be thrown on his associations with these "best friends." It has been surprising throughout the analysis of records to find no mention of Vernon in any of the social situations in which Ben was observed except the snow trip in H11. Certainly there was a relationship there which continued through the years, but of what nature or how satisfying to Ben we cannot guess.

The records of social behavior when Ben was in the low eleventh grade are limited to observations and ratings made in a classroom and on an ice skating party. The ratings in the two different situations by two different

observers have high agreement. Although the ratings in general have a trend toward the less desirable social behavior, the only two characteristics which make a significant drop are popularity and leadership (Figures 215, 216, and 217). His lack of popularity at the skating party is described thus: ". . . a fringer. . . . If conveniently situated, social contact may be made with him by anyone who happens to be present. . . ." His lack of leadership is shown in this statement: ". . . functions as a part of the group without particularly affecting the nature of the group's activity. Has little or no effect on others. . . ."

Actually, he was part of the most active group at the skating party. One observer believes "the fact that he was in these activities was probably largely because he was one of the few at the party who could skate at all." A composite of the various observations of this active group gives us this picture:

> Phil, Dick, and Dave, close friends for many years back, were out for all the fun they could create. Ben and Sam, when they arrived, joined this group in chasing each other around the rink or in playing crack-the-whip. They seemed quite free and having a grand time—though perhaps a little less energetic than Phil and Dick. A little later this game gave place to tag, and the spirit of recklessness was heightened considerably. Ben, who had been laboriously getting himself about, entered into tag for a while.

Outwardly, to the observer's eye, he did not seem to be very much concerned about his lack of prestige.

> A docile, quiet, inhibitive sort of behavior exhibited, though does not appear overly concerned about his lack of stimulus value and prestige. . . . Shrinks from making new adjustments with same sex . . . not so spontaneous as the others.

One cannot be sure from the data available, but there are indications that Ben had learned his social lesson concerning his relations with other boys: he would not be sought, he would not be greeted with enthusiasm, but if he took initiative he would be accepted by certain of the younger or less socially popular. There is reason to believe that this lesson may have been learned at a great cost to his feelings of security and to his own personal happiness.

The spring that Ben was sixteen (grade H11) we see him on an excursion to the Sierras for snow sports during the first week of March, on a roller skating party, and at the Institute the last of March. In general, the trend in his social ratings is upward. This is especially marked for leadership. On the Sierra trip and at the skating party, Ben's relations with boys in mixed-sex groups can be seen. (See Figures 215, 216, and 217.)

Thirty-four boys and twenty-one girls went on the snow trip to the

Sierras which extended from the evening of March 4 to the evening of March 5. Besides Vernon, who was mentioned by Ben as his best friend every year, there were several other boys on the trip with whom Ben had had satisfactory relations at previous times, according to the records. These included Ed, Carter, Rod, Sidney, Gordon, Wayne, Sam, Clayton, and Phil, Dick, and Dave.[38]

Vernon's father brought Ben to the station. On the train going to the mountains Ben sat in a double seat in the coach car beside Vernon and opposite Lanny when they first got on the train. "Lanny, Vernon, and Sidney did most of the violent wandering that night." They went into the smoker and smoked, got into an empty upper berth and kidded the girls below until they were made to come down by an adult, brought snow into the car and had a snow fight, but Ben "didn't attempt to keep up with them or go with them in their mischief." At 2:00 A.M. when the lights were turned out and many of the children were trying to get some rest, we note this observation:

> Five of them got on the backs of the seats. In the space of two seats were Glenn, Gladys Haug, Beatrice, Ben, and Freda (in that order) huddled on the backs of the seats. Then the Boy Scouts came through the car and tickled the girl's necks. Glenn was quite interested in Gladys. Ben left this group. He was too big and Freda objected to him. Lanny jumped into Ben's place. Freda said later: "There were a couple of reasons why I didn't sleep."

There is no description of his activity at the Lodge while skiing, tobogganing, and other sports were going on except that in the lobby "Lanny, Clayton, Leonard, and Ben crowded around the fire so that no one could approach." Coming home on the train "Ben and Vernon were together at first" and later these two were with Leonard and Clayton in a double seat. For a while Ben matched pennies with Vernon, Clayton, and Mary.

None of the boys mentioned in relation to Ben was particularly popular; several of them were odd. Even with such boys Ben did not stand out as a leader, nor did he impress the observers as being identified with any dramatic activity. One might judge that he was somewhat submerged in the group, as had been recorded during the previous two semesters.

On the roller skating party that same month, "Ben sat quietly with a few other boys when the 'couples only' round was going on. Seemed to have a good time when skating alone."

A week later at the Institute he was with several boys who were mentioned on his records previously. We see him in a situation which reveals rather clearly certain inadequacies which he still had in his relations with boys:

> Sam and Dwight had placed Ben's and Vernon's lunches on top of the garage roof, in return for their knotting of Sam's and Dwight's clothes in the dressing room. Ben was at a loss about getting up on the roof to retrieve them, and it was only with great difficulty that Vernon finally did so, and tossed them down to Ben.

In describing Ben's response to this, one observer states, "Ben adopted a rather hesitant and apprehensive role in the midst of the crude, roughhouse tactics of Dwight, Sam, and Vernon." The other observer states, "Ben took this in fairly good humor. However, I thought there was a faint derisive attitude among the boys toward him (I may be wrong), and I felt that Ben was just a little uneasy, slightly on the defensive with the boys." In recording the activities of Ben following this episode, the observers state:

> He ran around, kicking football, climbing swings, etc., with Dwight and Sam most of the hour. He played rather halfheartedly with Dwight and Sam, aiming passes with the football at the reclining Larry up near the east fence. Later Ben joined them in swinging on the tires, but, unlike them, he squealed with fear when he was used as a moving target by the others with the football and basketball.

On the rating sheet phrases used to describe him indicate that he was still considered "a follower," that he used "markedly affected gestures," and finally that he was "excessively concerned about the sort of impression he makes on his associates."

During that spring (high eleventh grade) he was completely ignored on the Guess Who test except for a mention that he was slightly talkative. He mentioned himself as one who fights and is restless but who avoids being the center of attention and is embarrassed in class. This was the most derogatory picture he ever gave of himself. He mentioned Vernon and Elliott Owen as his best friends, but no one mentioned him. However, on the Adjustment Inventory he stated that most people liked him pretty well.

In December of his last semester in high school Ben went to the Graduation Swim and Dance Party.[39] Although there were several boys present with whom Ben had been associated in other outings, it seems significant that the only person who made any gesture of welcome to him (as far as observers noticed) was Hugh. Hugh was by that time a nice-looking, well-developed boy, rather well accepted, a boy who had had a fat period between twelve and thirteen years.

The description of Ben's activities and relations at this party, as summarized in a staff discussion, reveals a boy who was not sought after but who would be accepted in boys' games. One wonders whether his preoccupation with basketball at this party may not have been motivated by an

intense desire to hold onto a situation where he *was* accepted and felt some security.

He came into the main hall shortly after he arrived. He stood over by the basketball game for about ten minutes right where the boys were playing. We couldn't tell whether he was waiting for a game to stop so he could join or whether he was just being ignored. But he did get in when several others joined. He then played continuously until after 9:00 o'clock or later. They hardly stopped a minute.

While he was standing there by himself the only person who made any gesture of welcome or contact was Hugh.

He played pretty hard in this group that gradually came together and which continued to play for over two hours (Van, Herbert, Jack, Hugh, Brooks, and some nonstudy boys). He was practically the only one who played the entire time. The group changed sufficiently so that he was the one who was in the game the longest. I was watching them almost the entire two hours, and I didn't see Ben smile once. He had a very solemn, sober look. As time progressed he began to look quite fatigued. From time to time I saw him wince and hold his hip, but he kept on doggedly until every one else dropped out.

After the basketball game he was sitting around the side talking. He got into one Chinese checkers game with Maurice and some other boys. Maurice won that game.

Later in the evening he was shooting baskets with Hugh. Hugh initiated the idea of coming over to listen to the orchestra; and Ben was the one who led them back to shooting baskets. Apparently he was feeling well enough to want to play an active game.

However, the contrast to Ben's relations with boys at this mixed-sex party and his relations with the boys with whom he played football at high school is well brought out in a report made by the physical education teacher:

This last term on several football trips that were made jointly by Tugwell–Tech–Central boys, he was very much a part of the group of Tugwell boys. The first trip I don't remember so well, but on the second one the Tugwell boys got the back seats on the way home, which is the seat they all want. He was one of the leaders, due to the fact, perhaps, that there were no real leaders in the bunch. They made various remarks to the Tech boys. He was very much one of the leaders in the Tech "Bulldog" yell, in which the Tugwell boys spelt out the letters B-U-L-L-S-H-I-T. At one time he said he didn't think I was very well pleased at what the Tugwell boys were doing. (It didn't bother me, but I was unusually quiet that day because of tiredness.) On this trip the Tech boys weren't the usual Tech leaders or the kind of kids that could make remarks back at them. The Tugwell boys enjoyed themselves very much, and he was a leader in the group.

The first trip the Central boys had the back seats, Tech in the front, and Tugwell in the middle. In the bus when they were returning from these trips the Tech boys made up yells like:

Mama's little sugar pie
We are the boys from Tugwell High
We don't smoke and we don't chew
And we don't go with the boys who do.
Woo-Woo-Woo-Woo

That's the general attitude of the boys toward Tugwell, the kind they wave white handkerchiefs at (not to individuals, but to the group). Ben always took part. He was accepted by the group on these trips, which is in contrast to the fact that the only person who spoke to him last night was Hugh.

This variation in his social position is brought out in other records. The vice-principal rated him as F in leadership, and his counselor and physical education teacher rate him as C at the end of the semester. One teacher in an interview reports her observations of this discrepancy:

Before and after class I noticed him talking to other football players, and also in the center of attention in their midst, he seemed acceptable enough to them. In the classroom, however, his manner changed and he shut up like a clam.

Another teacher also reported that during the fall of the high eleventh grade his behavior in the classroom was reserved:

Ben was rather reserved and standoffish from his classmates, although he was not unfriendly toward them. . . . At the end of fall became even more aloof from others than he had been previously.

His attitude toward classmates in the classroom was probably, in a sense, a reflection of his resentment of social rejection. In retaliation he says: ". . . Too many brainstorms in my class. They are always little guys who study all the time and what do they get out of life. Guess I'm just lazy. . . ."

Relations with girls. When he entered the senior high school at 14.5 years, Ben had definitely changed his outward behavior and attitude toward girls, as these comments indicate:

Has little use for girls—doesn't dance—snobbish attitude. Exhibits a negative phase—as though any personal interest in girls were unthinkable. Just no place for it in his present experience.

Has been at Clubhouse this period all semester, but pays *no* attention to girls there. Does not even notice them when they come up to table where he is playing cards.

No contacts with members of opposite sex; ignores their presence.

This may have been either a conscious or unconscious adjustment to his lack of success with girls, since he still made reference to girls when he was talking to an adult and there were no girls present. Furthermore, during that first semester in high school, he played ping-pong at the Clubhouse

with Jane five times, and cards with her twice. Here again his contacts were with a girl who was not among the socially mature or sophisticated. Jane was an outstanding example of a tomboy.[40] The boys liked her for her comradeship and skill in games rather than for her femininity. She never stopped in her efforts to beat the boys in games, as other girls did in order to be attractive, and showed none of the other traits of the feminine pattern of glamour.

It is exactly a year before we have any further records of Ben's relations with girls. During that time he had progressed well into the postpuberal period in physical development. Ratings in regard to relations with girls had gone even slightly lower. (See Figures 216 and 217.) By the next semester, however, when he was in the high eleventh grade, there was a slight upward swing in interest, drive, poise, and popularity—the first since he reached his high in the low ninth grade. The ratings were still, however, all below the mid-point of the scale.

On the week-end snow trip he was seen near girls, but "rather disdainful" in his attitude toward them. He avoided getting into any of the rough and tumble with snow and girls, even though some of the boys he was with were active in their mischief. He was given the lowest rating on the scale in interest in girls on this excursion. In spite of this behavior, in talking with boy companions at the Institute he indicated a definite interest in girls.

At the Swim and Dance Party the next fall, when he was sixteen and well developed physically, he still rated low in all his relations with girls. Observers stated that he had a "critical attitude" and "looks down on 'femmes.' " Quotations from three of the observations sum up his dilemma:

> I think he would have liked to dance. But he didn't have the opportunity to or didn't have the courage to ask any of the idle girls. I sometimes wonder why those boys don't ask the girls to dance.

> They are probably afraid they will get turned down, and are afraid to ask those not with boys because they might be asking someone who was not acceptable and it would endanger their own social prestige.

> While I was sitting around with Ben, we started talking about going home, and he asked me where I was going, and I said that I was going down Telegraph, and said I would give him a lift. I said that I was going over to Jules to get a milk shake. He didn't respond right away, but he went along. While we were at Jule's, about twenty of the kids came in, and he talked to quite a few of them passing by. I said it was a good party, but I thought there should have been more girls. He said, "Yes, I was surprised there weren't more! I thought there would be. That's why I didn't bring a girl." He thought there would be plenty of girls to dance with. He probably would have liked to dance. He agreed with me that there should have been more girls.

Throughout the whole period of the study, Ben indicated (Adjustment Inventory) that boys liked him better than girls, except at the peak of his fat period, when he stated he was not popular with either. This differential in his relations with boys and girls is supported by the ratings of observers beginning with the last year of the puberal cycle (Figure 216). But from the first semester in junior high school to the end of his first year in senior high school, Ben wished that boys and girls would like him better. He stated throughout that he was not like the boy who "has more girl friends than any of the other fellows," and said he did not wish very much to be like him. However, when he was in senior high school he was not quite so emphatic about this.

Relations with teachers in school. His first semester in senior high school at the beginning of his postpuberal period brought a slight improvement in academic grades owing to the fact that he got an "A" in German. Early in the fall, Mrs. Ruppert came to the advisor to see about Ben taking German instead of Spanish. She was "very pleased with his improvement" and said that "Ben had refused to go to the movies Wednesday night because he wanted to stay home and study."

His teacher reported later in an interview:

> Ben had some pride in his German descent. His father and mother spoke German and had provided him with some facility in the language. In class he rattled along, speaking the language, and slurred the endings so they could not be heard. In the tenth grade, he enjoyed showing off his knowledge of German.

At the end of the low tenth grade his German teacher marked him high in interest, achievement, and college aptitude, but his other two academic teachers rated him only average in interest and below average in achievement and college aptitude. The teacher in the Personal Management class adds, "Lacks dependability, needs help and supervision in work."

During that first semester in senior high school he stated on the Activities Survey that he belonged to the Boys' League and to the Student Body. It was somewhat unusual to list the Boys' League since every boy in school automatically belonged. There were a very few instances, if any, of a boy stating he belonged to the Student Body. This may have been an indication of his need for belonging to a group and the importance that these memberships held for him.

He added that he was on the first football team. As far back as the fall when Ben was ten and a half years old, his mother stated that his favorite game was football. This interest, which took so much of his time during Clubhouse days, and during the semiannual examination days at the Institute, then became incorporated into his school activities. Later records

seem to indicate that this was his most satisfying social contact in senior high school. During the second semester of the tenth grade he participated in no school activities, either social or athletic. His school grades were slightly lower than in the first semester. Absences from school began to be a problem.

In the eleventh grade, his grades declined decidedly. (See Figure 209.) Actually, this decline in the average was caused by the fact that he did not keep up his excellent work in German, and he had so much difficulty with geometry that he dropped it. At the close of the low eleventh grade his teachers (except for the teacher of German) rated him higher in achievement and college aptitude than his teachers of the previous year—above average rather than below average. In physical science, however, he was given next to the lowest ranking in interest.

By the end of the high eleventh grade, his geometry teacher said, "Ben just doesn't have time for study. Attendance record is fierce." And his German teacher (a different one from the one quoted previously) stated:

> Ben has been out fourteen days and, of course, received an "incomplete," but his work has been very poor, ever since the first week of the marking period. He comes quite unprepared, and when there is a test, he moans and looks at me appealingly, as if asking for help. Mentally, there is nothing wrong, though he seems to be getting to the point where German is hard for him, and I think he has acquired the habit of not studying because he got his German by "ear." His eyes seem to be bothering him considerably, also.

In the eleventh grade he belonged to the Boys' League and played on the football team. In the spring he also joined the Glee Club and took part in the Follies Operetta. During these three semesters he was absent from school twenty, nineteen, and seventeen days. Most of the causes he listed were due to personal illness (fifteen, thirteen, and eleven times, respectively)—colds, headaches, and physical mishaps. At the close of this period he had the lowest adjustment score concerning his feelings and attitudes toward school. (See Figure 208.)

In November of his senior year, his counselor made this note:

> He is still doing poorly in academic work. Boys' Glee is the only subject he really likes. . . . Says he doesn't work at school because he isn't sure he will ever need what he is taking because he hasn't the slightest idea what he wants to be. . . .
>
> His program card at that time indicated that he was playing school football, planned to belong to the *A Cappella* Choir or the Glee Club, and to Boys' Dramatics. One of his preoccupations at the time was athletics. Athletics is usually on his mind. His weight, of course, helps him a good deal, although it didn't help him much in junior high school.

Arrangements were made so that Ben could graduate in January instead of June by relinquishing college accrediting. Then this note by his advisor:

> Ben is graduating early without finishing course for college. . . . He has not done any better in school work, however (even though no homework to do).

And just before Christmas, the principal sent this note home to Ben's parents:

> Ben must pass in all six subjects he is taking this semester to graduate in January. I am told that he has an "incomplete" in geometry. Unless he passes in geometry as well as all his other subjects, he will not be able to graduate this semester.

His week-end diary early in January gives evidence that he made some effort during the last lap to graduate:

> Friday—I had just finished a German make-up test which took from 2:40 to 3:50½.
>
> Saturday—I go to the library and study for an hour, then I go home to bed early, about 9:00.
>
> Sunday—I came home and studied for my make-up tests of which I have a lot.

However, it was to no avail. He received an "incomplete" in geometry and failed to graduate. The next semester he agreed to take typewriting at night school to make up the points needed for graduation. He did not complete this, and therefore again in June failed to graduate.

His German teacher, who had given him an "A" in the tenth grade, was interviewed that June and made these comments about him:

> After the tenth grade Ben became independent of what was taught and maintained a slovenly attitude toward his work from then on. He is a "D" student. Has very poor work habits and has never really settled down at school.

The teacher of English and public speaking stated:

> He was brilliant but lazy. He got an "F" on one assignment and the next time conspicuously copied from his neighbor's papers. When called on this activity, Ben said in a matter-of-fact way, "If I don't you'll give me an 'F,' " and he went on copying from others through to the end of the term. I gave him a "C" because of the quality of his oral work and because of books and poetry that he read in class. He was coherent in his thinking about what he read, as was evidenced in his reports in class. He seemed to be acceptable to most of his classmates.

The report of the interview with Miss S., Ben's teacher in physical science and physiology in the low eleventh and low twelfth grades states:

Miss S. felt that she never reached Ben during either of these semesters. He didn't do any work, and his failures were never serious matters to him. Sometime ago Miss S. had Ben's sister, Lotta, in a class at Tugwell and recalled her flashing eyes and very much awake attitude. In contrast to her, Ben seemed to be completely asleep. Ben rarely volunteered any comments in class. He maintained a detached and aloof attitude. Before and after class Miss S. noticed him talking to other football players and also, in the center of attention in their midst, he seemed acceptable enough to them. In the classroom, however, his manner changed and he shut up like a clam.

Miss S. was impressed with the efficient way in which Ben handled himself in taking in and checking out books while he had this job in the book room.

During this final semester of his school career he had forty-six absences, thirty-six of which were attributed to illness—headaches, colds, injuries, He was hurt in football several times, and he said he was getting asthma. His mother was ill with more severe and more frequent attacks of asthma, and his brother was operated on for the second time.

Summary of postpuberal period. Entrance into senior high school seemed to give Ben a new lease on life. The success which he gained easily in his beginning classes in German because it was the language spoken in his home gave him a renewed interest in schoolwork. Making the high school football team during the first semester would have been a boost for any boy; for Ben it meant the culmination of his dreams. But before the first year was over the impetus from these successes was deteriorating, and the promise of personal integration during the postpuberal period was waning.

Ben was put on the football team because of his body bulk. Actually, he was much too immature physically for the strenuous demands of competitive interscholastic team games. At the beginning of the postpuberal period heart and lung power and organic balance still lagged behind body size. Combined with this lack of physiological readiness were Ben's inadequacies in motor skills. The task of being a good football player was a difficult one. His headaches, fatigues, and injured pelvis were probably due in part to genuine physical inadequacies intensified by the frustrations which these experiences engendered.

But through football Ben gained his most satisfying social relations throughout the postpuberal years. It afforded the only group of boys where he had a real place at a time when belonging to a small, intimate group looms relatively important in the lives of adolescents. The prestige of being on the football team, however, never carried over into other social activities in the school.

Ben gradually built a wall around himself—he was reserved in relations with boys, he showed discrimination in making overtures to boys—psycho-

logically he seemed to be protecting himself from hurts. In this way he grew in ability to be accepted and to get along with certain of the less popular but mature boys in boys' activities.

In mixed-sex groups the picture changed. When girls were around, Ben was a fringer. Even his boy companions in sports paid little attention to him. The girls ignored him. Gradually, Ben too ignored the girls. Outwardly he posed as one who had little use for women, but it was not difficult to detect the sour grapes flavor of this attitude. He went to the mixed parties, he talked with boys about girls, he discussed them with adults. But the normal development of his sexual life, which should have been expressed during this period in warm, personal relations with a girl, was thwarted.

In the classroom Ben participated rarely. The quality of his work declined steadily. He was absent more and more. A last-minute effort was made to lighten his program, to bring pressure on his parents, to stimulate Ben. Ben tried, but the emotional load which weighed him down could not be lightened by a sudden resolve. The climax came; this intelligent, well-meaning boy failed to graduate from high school.

Ben was sick and tired and unhappy because he could not achieve the primary tasks of adolescence. His self-ideals and the reality of his accomplishments could not be harmonized. His longing for status and acceptance among his peers gained only limited satisfactions. He was thwarted in developing wholesome heterosexual relations. To come to terms with himself and life Ben needed new experiences in situations where his strong sense of responsibility and his longing for warm human relations might have outlets and rewards.

GENERAL SUMMARY AND COMMENTS ON THE METHOD OF CASE ANALYSIS

As stated at the beginning of this chapter, our primary purpose in presenting the case of Ben is to show how his four phase pattern of somatic development can be used as a framework upon which other developmental data may be arranged. It seems to us that data so grouped have more meaning than they have when arranged upon a framework of chronological age alone, as is usually done.

SUMMARY OF CASE

A brief and generalized summary of the case of Ben may bring to sharper focus our hypothesis.

Prepuberal period. This was a period when Ben was socially, emotionally, and physically close to the period of later childhood. But there were

unmistakable evidences that a change was taking place, a change which was reflected in his relations with his family, his budding desire for more freedom, and his restless, talkative behavior in school. These changes in inner feelings and social relations paralleled the somatic signals that adolescence had begun: accelerated leg growth, appearance of vellus hair in the pubic area, and accelerated growth of testes.

The fact that adolescence began for Ben during a period of family crises and at an unusually early age brought emotional concomitants which showed their effect throughout adolescence.

Puberal period. The first half of the puberal period for Ben was a time of increased consciousness of self and of his masculine goals. It brought a strong identification with his peers and a desire for recognition by them. But the early adolescent fat period which Ben experienced gave him a male-inappropriate body which he could not accept and which inspired teasing and rejection instead of acceptance by the other boys. Moreover, the asynchronous pattern of his growth made him awkward and unskillful in games at a time when he particularly desired athletic prestige.

During the second half of the puberal period Ben achieved some satisfaction of his strong desire for recognition through friendships with the younger and less popular boys. But he still found it difficult to accept this compromise with his self ideals. With developing sexual maturity his interest in girls increased but his general social immaturity coupled with his feeling of inadequacy prevented him from achieving the success that one might expect from an early maturing boy whose body during this part of the period had become muscular and male-appropriate.

Ben felt less and less dependent upon his family for companionship and more irked by their controls even though he still showed a close emotional identification and carried many home responsibilities. His personal problems were mirrored in the quality of his school work which declined steadily during most of the puberal period. Toward the close of the period, with the loss of excess fat tissue and the achievement of better social relations with his peers, his school grades improved.

Postpuberal period. The postpuberal period for Ben was one of somatic integration, and the development of muscles, shoulder breadth, and body hair. One might conclude that it was also a time of social integration. He attained athletic status and found a place in a small group of boys at a time when belonging to an intimate group was important. He ceased striving for contacts with boys who rebuffed him and withdrew from seeking favors from girls.

Outwardly, Ben gave the impression of greater poise and self-sufficiency. But there were evidences that his behavior was a mask for his inner feel-

ings, a protection of his self from the trauma of rejection and failure. His ego ideals still remained far beyond his accomplishments in school, in athletics, in relations with both boys and girls. These failures due to cumulative experiences over the years gave him a sense of frustration, of inadequacy, of rejection that brought loneliness, unhappiness, and perhaps some bitterness in their wake.

DISCUSSION OF THE METHOD OF ANALYSIS

From this summary several conclusions regarding the method of case analysis appear to be valid.

First, the arrangement we have used emphasizes the unique continuity in the process of development for this particular boy. Frequent reference to the sequence of distinct developmental phases of somatic growth gives enhanced meaning to changes in his emotional and social behavior. The possibility of correctly interpreting his overt reactions at any given time during adolescence is significantly increased by accurate knowledge of the particular maturational phase through which he was then passing.

Second, the timing of the beginning of the adolescent period in relation to the chronological age of a boy, as well as to the developmental status of other boys, is important. The precocity of Ben's somatic development was a conditioning factor to be reckoned with during the prepuberal, puberal, and postpuberal phases. It contributed to the goals which he set for himself and to the expectancy of performance which others held for him. It established a role which he struggled to achieve. When he failed to achieve this role, the failure disrupted his personality structure; when he made progress toward achievement his personality became better integrated.

Third, the idiomatic characteristics of somatic changes during adolescence for any boy may bring specific problems of self-acceptance and social adjustment. For Ben, the *form* which his body growth took during early adolescence brought deep-seated problems in his ego structure. When, during the last part of the puberal period, the masculinity of his body emerged from the cloak of fatty tissue which had enveloped it, Ben showed improvement in social adjustment, in academic achievement, and in emotional poise. Unfortunately, the psychological scars from earlier frustrations remained to hamper wholesome personality development.

For other boys the specific somatic variations which may be involved in personal adjustment during adolescence may differ. They may be anatomical and physiological changes peculiar to the second decade of life or somatic conditions which have a changed significance because of the adolescents' development. But in any case, these boys in the California Adolescent Study give convincing evidence that the course of somatic growth

during adolescence is an important thread in the pattern of personality development.

FOOTNOTES FOR CHAPTER XVIII

[1] See, for instance, Zachry and Lighty: *Emotion and Conduct in Adolescence;* Blos, P.: *Adolescent Personality;* and Stolz, H. R., and Stolz, L. M.: "Adolescent Problems Related to Somatic Variations." *43rd Yearbook,* Part I, National Society for the Study of Education, Chicago, 1944.

[2] See Chapter II.

[3] See Stolz, H. R., and Stolz, L. M.: *op. cit.*

[4] This preliminary analysis was made at the Child Development Center of the University of Chicago.

[5] See Chapter II.

[6] Exact data: 9.9 years—4 feet, 7.91 inches; 16.9 years—5 feet, 9.14 inches.

[7] Exact data: puberal onset, 10.75 years; end, 14.20 years; duration, 3.45 years; gain, 10.48 inches.

[8] Correlation between age at onset and duration of the puberal period —.367, P. E. ±.071. (See Figure 38, Chapter IV.)

[9] Of 67 cases, 19.4 per cent had a similar configuration. (See Figure 64d, Chapter V.)

[10] Correlation between age at onset and duration of the puberal period —.367 ±.071. (See Figure 38, Chapter IV.) Correlation between amount of puberal gain in height and age at onset —.483 ±.063; correlation between amount of puberal gain and duration of period .771 ±.033. (See Figures 50 and 55, Chapter V.)

[11] In 75 per cent of our cases the apex for leg length growth preceded the apex for height growth. In 20 per cent, of which Ben was one, stem length was synchronous and leg length prior to height apex. (See Tables 48 and 51, Chapter VIII.)

[12] Eighteen per cent of our cases showed correspondence in the direction of the growth rates of stem length and leg length in from 14 per cent to 26 per cent of the examination periods.

[13] See Chapter X.

[14] Exact data: chronological age, 16.65 years; skeletal age, 18.25 years.

[15] About one third of the boys had the maximum growth in hip width preceding the height apex, but only half of these occurred during the puberal period. Over half of these cases (52.24 per cent) had the apex of hip-width growth preceding the apex of shoulder width.

[16] Exact data: 15 millimeters, or .59 inch.

[17] Seventy-three per cent of the cases had shoulder width apex within the puberal growth period for height; slightly less than half of the cases had the apex following the apex for height.

[18] From 12.9 years to 13.9 years.

[19] Out of a total of 83 boys.

[20] He was one of 12 out of 67 boys who held the same quartile position throughout.

[21] Chronological ages at these points were 9.9 years, 10.75 years, 14.2 years, and 16.9 years.

[22] There were three cases among the heavy boys whose height was about the same as Ben's.

[23] Mean age for the group, 16.8 years.

[24] There were only two or three instances of this by the two hundred children in the study during the eight years.

[25] Responses obtained from cumulative records organized by Dr. Caroline Tryon, from U. C. Inventory I.

[26] These judgments throughout the study were obtained through use of the *Reputation Test.* For analysis of characteristics admired by boys and girls during the puberal cycle, see Tryon, Caroline: "Evaluations of Adolescents Personality by Adolescents." Monograph, Society for Research in Child Development, **4**:1–83, 1939.

[27] See Chapter III for description of these ratings.

[28] Ratings were made independently by three staff members on the social rating scale used at the Institute on examination days. The data were analyzed by Dr. Caroline Tryon.

[29] Dwight was .7 year older and in Phase I of the puberal cycle. The next year Ben and Dwight mentioned each other as "best friends."

[30] Bryce at this time was 14 years old, 1.1 years older than Ben but slightly behind him in physical maturity.

[31] Analysis of Clubhouse Activities, by Jaffray Cameron. Unpublished manuscript, on file Institute Child Welfare, University of California.

[32] A girl, Eileen, also played with him several times. (See discussion of relations with girls, page 474.)

[33] Whether this may have some relation to the fact that the boys he played with were chronologically older is not clear.

[34] Dwight was never listed on the Clubhouse records in relation to Ben. He was with Ben at the Institute in the spring of 1935 (see notes, page 469) and in the fall of 1936 (see page 470.)

[35] Of this group Carter was the only boy who appeared on the Clubhouse records with Ben. They played football together three times in the fall of 1935. He is described on page 470. This group, though all older than Ben, was chronologically nearer than previous groups.

[36] Gus was at the same position in physical development and only three months older.

[37] The case of John Saunders has been analyzed and published in *Development in Adolescence* by H. E. Jones and Associates, Appleton-Century-Crofts, Inc., New York, 1943.

[38] Ed was one of the group who played football with Ben in the Clubhouse yard during the fall of 1935 and Ben's most frequent companion, spring, 1936. (See page 470.) On the snow trip the girls mentioned how Ed had grown.

Carter was one of the little boys in the football group, fall, 1935; he was also mentioned at the Institute with Ben, fall, 1936. (See page 470.)

Rod was the "sex-inappropriate fat boy" who played in the football group and who buzzed around with Ben, fall, 1935. (See pages 470 to 471.)

Sidney was mentioned by Ben as one of his best friends, spring, 1936. (See page 472.)

Gordon was in the group at the Institute, fall, 1936, with which Ben was successful. (See page 480.)

Wayne was his constant companion at the Clubhouse, fall, 1936. (See page 481.)

Sam was one of the three mature boys with whom Ben played successfully at the Institute, spring, 1937, and who was in the active group on the skating party. (See pages 482 to 483.)

Clayton—the big, heavy-framed boy, good natured, socially shy—played football with Ben, fall, 1935. (See page 470.)

Phil, Dick, and Dave were leaders in the active group on the skating party, fall, 1937. (See page 483.)

[39] The downward trend of the lines in Figures 215, 216, and 217 may be misleading as the point is based upon one rating toward the end of the H11 semester which presumably was a composite judgment of the various staff members. It was made on Ben's behavior at the Graduation Swim and Dance Party. This prevents one from seeing the variation in Ben's behavior in different situations or as seen by different observers. However, it has been noticeable that during the postpuberal period there was much less scatter in the ratings given to Ben. This may have been due to an integration in his behavior that made him behave more consistently, or it may have been due to the fact that the raters had come to a more definite decision as to what kind of boy he was.

[40] For a more complete description of Jane, See Case 28 in Supplement to Monograph by Caroline Tryon, "Evaluation of Adolescent Personality by Adolescents." Society for Research in Child Development, **4**:113, 1939.

APPENDIX A

MEDICAL AND ANTHROPOMETRIC EXAMINATION FORM (MAY '32—MAY '33)

Examiner............. STUDY OF ADOLESCENTS Case No...............

Name Age School Date.................

(Exam)	Type ratings: body	posture scapulae R L
Weight	Handedness: R L Amb	Knee align. ( ) ||) (1 2 3
Height	Eyedness: R L Amb	Foot align. ( ) ||) (1 2 3
Sit. height	Skin: vascularity 1 2 3 4 5	acne birthmark
Stem length	Hair: axillary O A B C D	pubic O A B C D
Bi-acromial	Bones: width / length	enlarged epiphyses rosary deform.
Biiliac	Musc. develop:	Sub-cut. tissues develop:
Bitrochant	arms 1 2 3 4 5	L. arm 1 2 3 4 5
Chest breadth	legs 1 2 3 4 5	abdom. 1 2 3 4 5
Chest depth	trunk 1 2 3 4 5	L. hip 1 2 3 4 5
	Lymph nodes:	
Costal angle 1 / 2	cervical 0 1 2 3 4 5	hard soft fluct. R. L.
	submax. 0 1 2 3 4 5	hard soft fluct. R. L.
Neck circum.	axillary	inguinal
Chest circum. Nipple level Sub-mam.	Nose: normal discharge asymmetry obstruct. R L	
	Pharynx: normal injection granulation discharge	
	Tonsils: 0 1 2 3 4 5 inject. exudate crypts buried	
Arm circum. L	Ears: normal wax obstruct. discharge perforat. R L	
Thigh " L	Eyes: normal injection granulation ptosis strabismus R L glasses	
Leg " L	Thyroid: 0 1 2 3 4 5	
Head Breadth	Heart sounds: normal arrythmia murmur accentuation	
Head Length	Reflexes:	
Grip R.	Pupil L. 0 1 2 3 4 5 R L	Patellar 0 1 2 3 4 5 R L
	Pupil D.. 0 1 2 3 4 5 R L	Achilles 0 1 2 3 4 5 R L
Grip L.	Biceps 0 1 2 3 4 5 R L	Abdom. 0 1 2 3 4 5 R L
	Triceps 0 1 2 3 4 5 R L	Cremast. 0 1 2 3 4 5 R L
Pull	Abdomen: convex flat concave hernia R L	
Thrust	Extremities:	

Summary: Develop. 1 2 3 4 5 Nutrition 1 2 3 4 5 Handicaps 0 1 2 3 4 5

Ht. Age / % variation
Wt. Ht. Age / % variation
Length Breadth Index /
Cephalic Index /
Dental Dev. Index /

Teeth:

c = carious
e = extraction

2nd
1st
R 8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 8 L
1st
2nd

Report to Parents:

Ht. for Age :Wt. for Ht. & Age
Dent. Dev. :Sub. cut. Fat
Musc. Dev. :Musc. tone
:Posture

Handicaps:

Faulty Regime:

MEDICAL AND ANTHROPOMETRIC EXAMINATION FORM
(AUGUST '33—AUGUST '39)

Examiner............. STUDY OF ADOLESCENTS Case No...............

Name Age School Date

(Exam)
Weight
Height
Sit. height
Stem length
Biacromial
Biiliac
Bitrochant
Chest breadth
Chest depth
Costal angle 1 2
Neck circum.
Chest circum.
Nipple level
Sub-mam.
Arm circum. L
Thigh " L
Leg " L
Head Breadth
Head Length
Grip R.
Grip L.
Pull
Thrust

Type ratings: body posture scapulae R L
Handedness: R L Amb Knee align. ( ) ||) (1 2 3
Eyedness: R L Amb Foot align. ( ) ||) (1 2 3
Skin. acne birthmark
Hair: axillary O A B C D pubic O A B C D
Bones: width length enlarged epiphyses rosary deform.
Sub-cut. tissues develop: Blood Pressure:
L. arm 1 2 3 4 5 Systolic
abdom. 1 2 3 4 5 Diastolic
L. hip 1 2 3 4 5
Lymph nodes:
cervical 0 1 2 3 4 5 hard soft fluct. R. L.
submax. 0 1 2 3 4 5 hard soft fluct. R. L.
axillary 0 1 2 3 4 5 hard soft fluct. R. L.
inguinal 0 1 2 3 4 5 hard soft fluct. R. L.
Nose: normal discharge asymmetry obstruct. R L
Pharynx: normal injection granulation discharge
Tonsils: 0 1 2 3 4 5 inject. Injected. exudate crypts buried
Ears: normal wax obstruct. discharge perforat. R L
Eyes: normal injection granulation ptosis strabismus
R L glasses
Thyroid: 0 1 2 3 4 5
Heart sounds: normal arrythmia murmur accentuation
Abdomen: convex flat concave hernia R L
Extremities:
Teeth:

2nd
1st
R 8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 8 L
1st
2nd

■ = carious ● = filled e = extracted

Ht. Age / % variation
Wt. Ht. Age / % variation
Length Breadth Index /
Cephalic Index /
Dental Dev. Index /

Recent Illnesses: 0 1 2 3

Report to Parents:

Ht. for Age :Wt. for Ht. & Age Handicaps:
Dent. Dev. : Sub. cut. Fat
Musc. Dev. :Musc. tone Faulty Regime:
:Posture

APPENDIX B

UNIVERSITY OF CALIFORNIA—INSTITUTE OF CHILD WELFARE RATING SCALE

PHYSICAL EXAMINATION

Case ________
Rater ________
Date ________

I. *Beauty of face and coloring* (*disregarding expression*)

Very attractive. Good coloring, unusual beauty of features.	No outstanding merits or demerits.	Unattractive, colorless, asymmetrical, or otherwise unpleasing face.
1 2	3 4 5	6 7

II. *Pleasantness of characteristic facial expression*

Characteristic facial expression is exceptionally pleasant, smiling, cheerful, interested, animated.	Average for age; child's characteristic expression is neither extremely pleasant nor unpleasant.	Child's characteristic facial expression is exceptionally unpleasant—usually frowning or gloomy or disappointed or sad or pouting or blank or unanimated, etc.
1 2	3 4 5	6 7

III. *Attractiveness of physique and carriage*

Well proportioned, excellent posture, well knit. Neither too fat nor thin.	Average. Not unpleasing, not outstanding.	Badly proportioned; excessively fat or thin; poor posture, loose jointed.
1 2	3 4 5	6 7

IV. *Masculinity—Femininity*

Very masculine.	Average boy or girl qualities.	Very feminine.
1 2	3 4 5	6 7

* V. *Bodily cleanliness*

Clean nails, ears, teeth, scalp, skin.	Not noticeable. Apparently left to his own standard on the whole.	Slovenly. Dirty nails, ears, teeth, scalp, skin.
1 2	3 4 5	6 7

VI. *Restlessness*

Child cannot stand or sit still with selfpossession; exceptionally restless.	Average self-possession when standing, sitting, watching, etc.; average restlessness.	Child can stand or sit still with exceptional absence of childish restlessness.
1 2	3 4 5	6 7

VII. *Talkativeness*

Child is very talkative, verbalizes freely and continually. Loquacious, a prattler.	Average. Not inhibited in speech but not loquacious.	Child is relatively silent, seldom verbalizes unless necessary. Brief, speaks little.
1 2	3 4 5	6 7

APPENDIX B—(*Concluded*)

UNIVERSITY OF CALIFORNIA—INSTITUTE OF CHILD WELFARE RATING SCALE

* VIII. *Reaction to examiner*

Excessive anxiety to please; obviously feels need to make good impression.	Average; on the whole is matter of fact; tends to treat examiner as an equal.	Either marked negativism; or indications of marked inadequacy; surly, antagonistic, very bashful, terribly embarrassed.

1 2 3 4 5 6 7

* IX. *Adaptability to instructions*

Comprehends instructions immediately.	Average; some repetition may be necessary especially with regard to details.	Complete lack of comprehension after considerable explanation.

1 2 3 4 5 6 7

* X. *Apprehensiveness*

Anxious, frightened, or worries at the prospect of a situation which is new and unknown, unpleasant or dangerous, i.e. physical examination. Shows anxiety in a new situation.	Occasionally slightly apprehensive at prospect of the unfamiliar.	Child never worries or becomes frightened in advance; is entirely carefree and unapprehensive. No evidence of anxiety in a new situation.

1 2 3 4 5 6 7

* These items were dropped in the Spring of 1934, on the basis of their not being clearly observable, or readily distinguishable in the examination situation.

APPENDIX C

SCHEDULE OF FIRST EXAMINATION—BOYS

Dates	*Cases*	*Total Number*
1–21–32	22, 30, 32, 34, 38, 40	6
1–28	18, 26, 36, 48, 50, 56	6
2–4	6, 14, 52, 54, 60, 66	6
2–11	58, 64, 72, 74	4
2–14	70	1
2–18	78, 80, 82, 84, 86, 88, 92, 96	8
2–25	62, 68, 98, 104, 110, 112, 116, 140	8
3–3	100, 106, 108, 114, 130, 134	6
3–10	90, 118, 120, 122, 124, 126	6
3–17	128, 136, 216, 218, 246	5
3–19	102	1
3–31	204, 206, 208, 212, 214, 220, 224, 228	8
4–7	188, 190, 202, 234, 242	5
4–14	176, 180, 194, 198, 230, 232, 236	7
4–21	142, 144, 146, 158, 164, 170	6
4–26	150, 166, 168, 182, 184, 248	6
5–5	132, 154, 162, 172, 178, 226, 244, 250	8
5–12	2, 4, 8, 10, 12, 24, 42, 44	8
3–30–33	292	1
4–6	294, 300, 302, 304	4
5–4	296, 298	2
		112

APPENDIX D

INTERVALS BETWEEN EXAMINATIONS (IN YEARS)—BOYS

Case	*Beginning*		*Examination*														*Termination*	
Number	Date	Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Date	Age
2	5–12–32	11.9	.7	.3	.5	.5	.5	.5	.5	.4	.6						10–29–36	16.4
4	5–12–32	11.3	.7	.3	.5	.5	.5	.5	.4	.5		1.0	.5	.5	.5		10–6 –38	17.7
6	2–4 –32	10.1	.6	.5	.5	.6	.6	.4	.5		1.0	.6	.4	.5	.5		10–27–38	16.8
8	5–12–32	11.1	.7	.3	.5	.5	.5	.5	.5	.4	.6	.5	.6	.5	.4	.4	3–9 –39	17.9
10	5–12–32	11.7	.7	.3	.5	.4	.5	.5	.5	.5	.5	.4	.6	.4	.4	.4	3–23–39	18.5
12	5–12–32	10.7	.7	.4	.4	.6	.4	.5	.5								12– 5–35	14.2
14	2–4 –32	12.0	.7	.4	.6	.5	.5	.5	.6	.5	.4	.5	.6	.4	.6	.5	5–4 –39	19.3
18	1–28–32	10.8	.8	.3	.6	.5	.6	.4	.7	.6	.6	.5	.5	.5	.5		11–3 –38	17.7
22	1–21–32				1 examination													
24	5–12–32	10.9	.7	.3	.5	.5	.5	.6	.4	.6	.5	.4	.5	.4	.5		9–22–38	17.3
26	1–28–32	11.1	.7	.3	.7	.7	.4	.5	.5	.6	.5	.4	.6	.4	.5	.5	4–27–39	18.4
30	1–21–32	10.9	.6	.4	.6	.4	.6	.5	.5	.4	.6	.4	.6	.5	.5	.6	5–4 –39	18.1
32	1–21–32	10.7	.7	.4	.5	.5	.6	.5	.5	.5	.5	.4	.6	.4	.6	.5	5–4 –39	18.0
34	1–21–32	10.8	.7	.4	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.7	5–4 –39	18.1
36	1–28–32	10.9	.7	.4	.6	.5	.5	.5	.5	.5	.5	.5	.5	.4	.6	.4	2–23–39	18.0
38	1–21–32	10.9	.7	.4	.6	.4	.6	.5									3–14–35	14.1
40	1–21–32	10.9	.7	.4	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	2–23–39	18.0
42	5–12–32	11.8	.7	.3	.5	.5	.6	.5	.5	.5	.5	.5	.6	.3	.6		12–8 –38	18.4
44	5–12–32	11.1	.7	.3	.5	.5	.5	.5	.5	.5	.6		1.0	.4			5–26–38	17.1
48	1–28–32	10.8	.7	.4	.6	.5											3–8 –34	13.0
50	1–28–32	11.0	.6	.4	.6	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3–2 –39	18.1
52	2–4 –32	10.8	.6	.4	.6	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3–9 –39	17.9
54	2–4 –32	11.1	.5	.5	.5	.4	.5	.4	.6	.4	.6	.6	.6	.4	.5	.7	4–27–39	18.3
56	1–28–32	11.8	.7	.4	.5	.5	.6	.5	.5	.4	.6	.5	.5	.5			3–17–38	18.0
58	2–11–32	11.4	.7	.4	.5	.5	.5	.5	.5	.5	.6	.5	.5	.5	.5	.4	3– 2–39	18.5
60	2–4 –32	11.3	.6	.4	.6	.5	.6	.4	.5	.5	.5	.5	.5	.5	.5	.5	3– 9–39	18.4
62	2–26–32	11.5	.7	.4	.6	.5	.5	.5	.5	.5	.6	.4	.4	.4			4–21–38	17.7
64	2–11–32	10.9	.6	.4	.5	.6	.5	.5	.5	.4	.6	.5		1.0	.5	.5	3–16–39	18.0
66	2–4 –32	11.2	.6	.4	.6	.5	.7	.4	.6	.3	.6	.5	.6	.5	.5		11–3 –38	18.0
68	2–25–32	11.0	.7	.3	.6	.5	.5	.5	.5	.5	.5	.4	.6	.4	.6	.4	3–2 –29	18.0
70	2–14–32				2 examinations													
72	2–11–32	11.3	.6	.4	.5	.5	.6	.5	.5	.5	.5	.5	.6	.5	.5		11–3 –38	18.0
74	2–11–32	10.4	.6	.4	.6	.5	.5	.5	.5	.4	.6	.4	.6	.4	.6	.6	4–27–39	17.6
78	2–18–32	12.6	.6	.4	.5	.5	.6	.4	.6	.4	.6	.5	.5	.5			3–24–38	18.7
80	2–18–32	11.0	.6	.4	.6	.4	.6	.5	.5	.4	.6	.5	.6	.4	.6		10–6 –38	17.7
82	2–18–32	9.9	.7	.3	.6	.5	.5	.5	.6	.6	.6	.5	.6	.3	.6		12–15–38	16.8
84	2–18–32	11.1	.6	.4	.6	.5	.5	.5	.5	.4	.6	.5	.5	.5	.5	.6	4–27–39	18.3
86	2–18–32	11.6	.6	.4	.5	.5	.6	.4	.6	.4	.5	.5	.6	.4	.6	.6	5–4 –39	18.8
88	2–18–32	10.3	.6	.4	.5	.5	.5	.5	.5	.5	.5	.6	.5	.4	.5		9–15–38	16.8
90	3–10–32	11.5	.6	.3	.6	.6	.5	.5	.6	.3	.6	.5	.5				10–28–37	17.1
92	2–18–32	11.3	.6	.4	.5	.5	.6	.4	.5	.5	.6	.4	.6	.4	.6	.5	4–13–39	18.4
96	2–18–32	11.3	.6	.4	.5	.5	.5	.5	.5	.5	.5	.5	.6	.4	.6	.5	4–13–39	18.4
98	2–25–32				3 examinations													
100	3–5 –32	10.5	.6	.5	.5	.6	.5	.5	.5	.5	.6	.5	.5	.4	.5	.4	4–20–39	17.6
102	3–19–32	11.1	.6	.4	.5	.5	.5	.5	.5	.5							3–26–36	15.1
104	2–25–32	10.9	.6	.5	.5	.5	.5	.5	.5	.5			1.6	.5	.5	.4	3–23–39	18.0
106	3–3 –32	11.3	.6	.4	.5	.5	.6	.5	.5	.4	.6	.5	.6		.9	.4	3–16–39	18.3
108	3–3 –32	10.2	.6	.5	.5	.5	.5	.5	.6	.5	.4	.6	.6	.4	.5	.5	4–20–39	17.4

APPENDIX D—*(Continued)*

INTERVALS BETWEEN EXAMINATIONS (IN YEARS)—BOYS

Case Number	*Beginning* Date	Age	*Examination* 2	3	4	5	6	7	8	9	10	11	12	13	14	15	*Termination* Date	Age
110	2–25–32	10.2	.6	.4	.5	.5	.6	.5	.5	.4	.6	.5	.5	.5	.5	.4	3–16–39	17.2
112	2–25–32	10.8	.7	.4	.5	.5	.5	.5	.6	.6	.5	.4	.6	.4	.5	.5	3–30–39	18.0
114	3–3– 32	10.8	.6	.5	.5	.4	.6	.5	.5	.5	.5	.5					4–8 –37	15.9
116	2–25–32	10.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.6	.4	.5	.4	3–16–39	17.4
118	3–10–32	10.9	.6	.4	.6	.5	.6	.5	.5	.4							4–2 –36	15.0
120	3–10–32	10.6	.6	.4	.5	.5	.6	.5	.5	.4	.6	.5	.5	.4	.6	.5	5–4 –39	17.7
122	3–10–32				1 examination													
124	3–10–32				3 examinations													
126	3–10–32	10.8	.7	.3	.6												9–21–33	12.4
128	3–17–32				3 examinations													
130	3–3 –32	10.3	.6	.4	.5	.5	.4	.7	.5	.5	.5	.4	.6	.4	.5	.4	3–2 –29	17.2
132	5–5 –32				3 examinations													
134	3–3 –32	10.0	.6	.4	.6	.5	.6	.4	.5	.6	.5	.5	.6	.5	.5	.4	4–20–39	17.2
136	3–17–32	10.2	.8	.3	.5	.5	.7	.4	.5	.5	.5	.5	.6	.4	.5	.4	3–30–39	17.3
140	2–25–32	11.1	.6	.4	.5	.5	.6	.5	.5	.5	.5	.4	.6	.4			3–17–38	17.1
142	4–21–32	10.9	.6	.4	.6	.4	.6	.5	.5	.4							5–7 –36	14.9
144	4–21–32	10.4	.7	.4	.5	.4	.6	.5	.5	.5	.5	.5	.6	.4	.5	.4	4–13–39	17.4
146	4–21–32	10.9	.6	.4	.6	.4	.5	.5	.6	.4	.6	.5	.5	.4	.6	.4	3–20–39	17.9
150	4–26–32	11.0	.7	.3	.5	.5	.6	.5	.5	.5	.5	.5	.5	.4	.5	.5	4–13–39	18.0
154	5–5 –32	10.6	.7	.3	.5	.5	.6	.5	.5	.4	.5	.6	.5	.5	.5	.4	4–13–39	17.6
158	4–21–32	10.3	.7	.3	.5	.5	.6	.5	.5	.5	.5	.5	.5	.5	.5	.4	4–20–39	17.3
162	5–5 –32	10.9	.7	.3	.5	.4	.7	.5	.5	.5	.5		1.1	.3	.6		12–8 –38	17.5
164	4–21–32	10.6	.8	.3	.5	.5	.5	.5	.6	.4	.6	.4	.6	.4	.5	.4	4–27–39	17.6
166	4–26–32	10.5	.7	.3	.5	.5	.6	.5	.5	.5	.5	.5	.5	.4	.6	.4	4–13–39	17.5
168	4–26–32	11.0	.7	.3	.5	.5	.6	.5	.5	.5	.5	.5	.6	.4	.5	.4	4–27–39	18.0
170	4–21–32	10.6		1.1	.4	.6	.6	.4		1.1	.5	.5	.6	.4	.5	.4	4–20–39	17.6
172	5–5 –32	11.0	.7	.3	.5	.5	.6	.5	.5	.4	.5	.5	.6	.4	.6	.3	4–20–39	17.9
176	4–14–32	10.6	.6	.4	.5	.6	.4	.5	.6	.4	.6	.5	.5	.4	.6	.4	4–20–39	17.6
178	5–5 –32	10.6	.7	.3	.4	.6	.5	.5	.5	.5							5–7 –36	14.6
180	4–14–32	10.7	.6	.4	.5	.6	.4	.5	.6	.5	.5	.5	.5	.5	.5	.4	3–30–39	17.7
182	4–26–32				1 examination													
184	4–26–32	10.1	.7	.3	.5	.4	.6	.5	.5	.5	.5	.4	.5	.5	.5	.4	2–23–39	16.9
188	4–7 –32	11.9	.6	.5	.5	.5	.4	.5									3–28–35	14.9
190	4–7 –32	11.4	.6	.4	.5	.5	.5	.6	.5	.5	.5	.5	.7		.9		12–8 –38	18.1
194	4–14–32				3 examinations													
198	4–14–32	11.5	.7	.4	.4	.6											5–24–34	13.6
202	4–7 –32				1 examination													
204	3–31–32	9.6	.5	.5	.5												10–19–33	11.1
206	3–31–32	10.3	.6	.4	.5	.5	.5	.5	.5	.5	.5	.5	.6	.5	.5	.3	3–16–39	17.2
208	3–31–32				3 examinations													
212	3–31–32	10.2	.6	.4	.5	.5	.6	.4	.5	.5	.6	.5	.5	.4			3–31–38	16.2
214	3–31–32				3 examinations													
216	3–17–32	9.9	.6	.5	.5	.5	.5	.4	.6	.4	.6	.5	.5	.5	.4	.5	3–23–39	16.9
218	3–17–32	10.7	.5	.5	.4	.5	.6	.5	.5	.5	.7	.4	.6	.3	.6	.4	3–23–39	17.7
220	3–31–32	10.6	.6	.4	.5	.5	.5	.6	.4	.5	.6	.5	.5	.4	.6	.4	3–23–39	17.6
224	3–31–32	10.6	.7	.3	.5	.5	.5	.5	.5	.6	.5	.5	.6	.3	.6	.4	3–16–39	17.6
226	5–5 –32				1 examination													
228	3–31–32	10.4	.6	.4	.5	.5	.4	.7	.5	.5							5–7 –36	14.5
230	4–14–32	10.6	.6	.4	.5	.5	.5	.5	.6	.5	.5	.5	.5	.4	.5	.4	3–9 –39	17.5
232	4–14–32	10.9	.6	.3	.5	.5	.6	.5	.5	.5	.5	.5	.5	.5	.5	.4	3–23–39	17.8
234	4–7 –32	10.8	.6	.4	.5	.5	.6	.5	.5	.5	.5	.5	.5	.4	.5	.5	3–23–39	17.8

APPENDIX D—(*Concluded*)

INTERVALS BETWEEN EXAMINATIONS (IN YEARS)—BOYS

Case	*Beginning*		*Examination*														*Termination*	
Number	Date	Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Date	Age
236	4–14–32	10.6	.6	.4	.5	.6	.5	.5	.5	.4	.6	.4	.6	.4	.5	.4	3–9 –39	17.5
242	4–7 –32	10.7	.5	.4	.6	.5	.6	.5	.5	.5	.5	.5	.5	.5	.5	.4	3–30–39	17.7
244	5–5 –32	11.5	.6	.4	.5	.5	.5	4	.5	.4	.6	.5	.5	.4	.6		9–29–38	17.9
246	3–17–32	11.0	.7	.3	.5	.5	.6										9–27–34	13.6
248	4–26–32				3 examinations													
250	5–5 –32	10.8	.5	.5	.4	.5	.5	.5	.5	.5	.5	.5	.5	.4	.6	.4	3–9 –39	17.6
292	3–30–33	11.9			.5	.5	.5	.5	.5	.5	.6	.5	.5	.5	.5	.4	4–13–39	17.9
294	4–6 –33	12.3			.5	.6	.5	.5	.5	.5	.5	.5	.5	.4	.6		10–20–38	17.9
296	5–4 –33	11.3			.4	.6	.5	.5	.4	.4	.6						10–8 –36	14.7
298	5–4 –33	11.7			.5	.6	.4										11–15–34	13.2
300	4–6 –33	12.3			.6	.5	.5	.5	.4	.5	.5	.4	.6	.4	.6		9–8 –38	17.8
302	4–6 –33	12.8			.5	.5	.5	.5	.5	.4	.5	.5	.5	.5	.5		9–8 –38	18.2
304	4–6 –33	12.3			.5	.6	.5	.5	.5	.5	.5	.4	.6	.4	.5		10–13–38	17.8

APPENDIX E

NUMBER OF SEMIANNUAL EXAMINATIONS IN SERIES FOR EACH BOY

Number of Examinations	*Case Numbers*	*Total*
1	22, 122, 182, 202, 226	5
2	70	1
3	98, 124, 128, 132, 194, 208, 214, 248	8
4	126, 204, 298‡	3
5	48, 198	2
6	246	1
7	38, 188	2
8	12, 296‡	2
9	102, 118, 142, 178, 228	5
10	2	1
11	114	1
12	90, 294,‡ 300,‡ 302,‡ 304‡	5
13	44,* 56, 62, 78, 140, 212, 292‡	7
14	4,* 6,* 18, 24, 42, 66, 72, 80, 82, 88, 162,* 190,* 244	13
15	8, 10, 14, 26, 30, 32, 34, 36, 40, 50, 52, 54, 58, 60, 64,* 68, 74, 84, 86, 92, 96, 100, 104,† 106,* 108, 110, 112, 116, 120, 130, 134, 136, 144, 146, 150, 154, 158, 164, 166, 168, 170,† 172, 176, 180, 184, 206, 216, 218. 220, 224, 230, 232, 234, 236, 242, 250	56
	Total cases	112

* Absent one.
† Absent two.
‡ Began spring, 1933.

APPENDIX F

TIMING OF PUBERAL GROWTH PERIOD FOR HEIGHT—67 BOYS

Case Number	*Age at Onset* Years (b)	*Age at End* Years (d)	*Duration Onset to End* Years	*Age at Height Apex* Years	*Age at Mid-point P.G.P. Height* Years (c)
8	12.35	15.30	2.95	13.85	13.83
10	12.95	15.85	2.90	14.35	14.40
18	11.75	15.40	3.65	13.80	13.58
24	14.20	16.15	1.95	15.25	15.18
26	11.45	14.65	3.20	13.15	13.05
30	13.75	16.75	3.00	15.70	15.25
32	12.05	15.15	3.10	13.65	13.60
34	14.15	16.65	2.50	15.65	15.40
36	14.35	16.80	2.45	15.35	15.58
40	12.75	15.25	2.50	14.25	14.00
44	12.35	14.85	2.50	13.35	13.60
50	13.85	16.35	2.50	14.35	15.10
52	14.15	16.65	2.50	15.15	15.40
54	12.90	15.90	3.00	14.90	14.40
58	13.25	16.35	3.10	15.25	14.80
60	12.60	15.15	2.55	14.20	13.88
62	12.90	16.00	3.10	14.45	14.45
64	12.70	15.75	3.05	14.70	14.23
66	13.65	15.60	1.95	14.20	14.63
68	13.35	16.80	3.45	14.35	15.08
72	12.10	15.15	3.05	14.15	13.13
74	10.70	14.20	3.50	12.25	12.45
78	13.85	16.90	3.05	15.40	15.38
80	12.30	14.80	2.50	13.85	13.55
82	11.20	14.50	3.30	13.90	12.85
84	13.95	16.45	2.50	15.40	15.20
86	11.90	14.90	3.00	13.35	13.40
88	12.05	14.55	2.50	12.55	13.30
92	13.60	15.60	2.00	14.10	14.60
96	12.55	15.05	2.50	13.55	13.80
100	12.40	15.00	2.60	12.95	13.70
104	11.75	14.25	2.50	12.75	12.75
106	13.60	15.60	2.00	14.15	14.60
108	12.05	14.60	2.55	13.05	13.33
110	12.45	14.50	2.05	14.00	13.48
112	12.65	14.80	2.15	13.15	13.73
116	12.25	14.75	2.50	13.25	13.50
120	12.35	14.90	2.55	13.95	13.63
130	14.65	17.50	2.85	15.60	16.08
134	13.35	15.50	2.15	13.90	14.43
136	12.65	15.70	3.05	14.65	14.18
144	11.30	14.35	3.05	13.25	12.83

APPENDIX F—(*Concluded*)

TIMING OF PUBERAL GROWTH PERIOD FOR HEIGHT—67 BOYS

Case Number	*Age at Onset* Years (b)	*Age at End* Years (d)	*Duration Onset to End* Years	*Age at Height Apex* Years	*Age at Mid-point P.G.P. Height* Years (c)
146	12.20	14.20	2.00	12.70	13.20
150	11.35	14.85	3.50	12.75	13.10
154	12.35	14.85	2.50	12.90	13.60
164	11.95	15.50	3.55	14.50	13.73
166	12.80	16.30	3.50	13.85	14.55
168	12.25	15.85	3.60	13.85	14.05
176	12.40	14.90	2.50	12.90	13.65
180	12.50	16.55	4.05	15.05	14.53
184	12.30	15.25	2.95	13.85	13.78
190	14.20	16.85	2.65	15.25	15.53
206	13.05	16.15	3.10	14.05	14.60
212	12.50	15.55	3.05	13.45	14.03
216	10.75	14.20	3.45	12.70	12.48
218	13.95	17.00	3.05	15.60	15.48
220	13.90	16.85	2.95	15.45	15.38
224	13.35	16.00	2.65	14.95	14.68
230	12.35	15.95	3.60	13.35	14.15
234	13.10	16.15	3.05	15.15	14.63
236	13.95	15.90	1.95	14.40	14.93
242	11.90	14.55	2.65	13.55	13.23
244	13.25	16.65	3.40	15.10	14.95
250	11.55	14.45	2.90	12.95	13.00
292	13.15	15.20	2.05	13.65	14.18
294	13.10	16.68	3.55	15.15	14.88
304	13.10	15.15	2.05	14.15	14.13

APPENDIX G

HEIGHT MEASUREMENTS AT DEVELOPMENTAL POINTS—67 BOYS

	Developmental Points				*Puberal Gain*	*Puberal Per Cent Gain*	*Puberal Rate of Gain*
Case Number	b − 3 Milli-meters	b Milli-meters	d Milli-meters	d + 3 Milli-meters	b–d Milli-meters	b–d	Average Millimeters per .1 Year b–d
8	1,480	1,550	1,754	1,778	204	13.1	6.9
10	1,392	1,455	1,676	1,723	221	15.1	7.6
18	1,457*	1,485	1,712	1,752	227	15.2	6.2
24	1,394	1,467	1,639	1,686	172	11.7	8.8
26	1,434†	1,451	1,739	1,783	288	19.8	9.0
30	1,479	1,531	1,760	1,790	229	14.9	7.6
32	1,560	1,622	1,864	1,918	242	14.9	7.8
34	1,508	1,563	1,736	1,775	173	11.0	6.9
36	1,502	1,567	1,757	1,793	190	12.1	7.8
40	1,332	1,392	1,579	1,618	187	13.4	7.5
44	1,400	1,468	1,669	1,745	201	13.7	8.0
50	1,511	1,575	1,794	1,844	219	13.8	8.8
52	1,531	1,599	1,791	1,834	192	12.0	7.7
54	1,514	1,567	1,754	1,786	187	11.9	6.2
58	1,489	1,539	1,724	1,764	185	12.0	6.0
60	1,381	1,453	1,617	1,657	164	11.2	6.4
62	1,330	1,386	1,612	1,642	226	16.3	7.5
64	1,441	1,492	1,718	1,767	226	15.1	7.4
66	1,521	1,596	1,722	1,747	126	7.8	8.4
68	1,478	1,551	1,792	1,823	241	15.5	7.0
72	1,479*	1,527	1,751	1,793	224	14.6	7.3
74	1,625†	1,644	1,922	1,955	278	16.9	7.9
78	1,463	1,519	1,713	1,748	194	12.7	6.4
80	1,450	1,514	1,733	1,775	219	14.4	8.8
82	1,405	1,471	1,740	1,795	269	18.2	8.2
84	1,471	1,528	1,733	1,766	205	13.4	8.2
86	1,498†	1,515	1,741	1,783	226	14.9	7.5
88	1,423	1,476	1,694	1,757	218	14.7	8.7
92	1,374	1,446	1,618	1,670	172	11.9	8.6
96	1,468	1,537	1,735	1,786	198	12.8	7.9
100	1,401	1,462	1,699	1,770	237	16.2	9.1
104	1,572*	1,617	1,803	1,853	186	10.8	9.3
106	1,482	1,558	1,732	1,774	174	11.1	8.7
108	1,397	1,458	1,686	1,735	228	15.6	8.9
110	1,421	1,494	1,697	1,760	203	13.5	9.9
112	1,515	1,591	1,762	1,826	171	10.7	8.0
116	1,332	1,375	1,570	1,611	195	14.1	7.8
120	1,477	1,537	1,737	1,782	200	13.0	7.8
130	1,479	1,535	1,738	1,758‡	203	13.2	7.1
134	1,545	1,621	1,797	1,830	176	10.9	8.2

APPENDIX G—(*Concluded*)

HEIGHT MEASUREMENTS AT DEVELOPMENTAL POINTS—67 BOYS

	Developmental Points				*Puberal Gain*	*Puberal Per Cent Gain*	*Puberal Rate of Gain*
Case Number	b − 3 Millimeters	b Millimeters	d Millimeters	d + 3 Millimeters	b–d Millimeters	b–d	Average Millimeters per .1 Year b–d
136	1,418	1,486	1,718	1,770	232	15.6	7.6
144	1,515*	1,570	1,824	1,882	254	16.1	8.5
146	1,457	1,526	1,700	1,743	174	11.4	8.7
150	1,475†	1,493	1,776	1,810	283	18.9	8.1
154	1,450	1,508	1,698	1,734	190	12.6	7.6
164	1,445	1,508	1,759	1,799	251	16.6	7.1
166	1,415	1,485	1,745	1,768	260	17.5	7.4
168	1,530	1,593	1,834	1,852	241	15.7	6.7
176	1,497	1,561	1,716	1,776	155	9.9	6.2
180	1,458	1,513	1,812	1,834	299	19.5	7.4
184	1,453	1,520	1,769	1,803	249	16.3	8.4
190	1,441	1,513	1,711	1,740	198	13.0	7.5
206	1,430	1,484	1,698	1,740	214	14.4	6.9
212	1,391	1,455	1,671	1,680‡	216	14.8	7.1
216	1,420*	1,457	1,723	1,742	266	18.2	7.7
218	1,412	1,465	1,661	1,674‡	196	13.3	6.4
220	1,478	1,529	1,725	1,744‡	196	12.1	6.6
224	1,566	1,627	1,773	1,803	146	8.9	5.5
230	1,416	1,480	1,764	1,796	284	19.1	7.9
234	1,517	1,577	1,852	1,882	275	17.4	9.0
236	1,599	1,659	1,780	1,810	121	7.3	6.2
242	1,403	1,472	1,662	1,727	190	12.9	7.2
244	1,501	1,544	1,800	1,818	256	16.5	7.5
250	1,510*	1,549	1,771	1,804	222	14.3	7.7
292	1,498	1,561	1,742	1,800	181	11.5	8.8
294	1,432*	1,471	1,688	1,702	217	14.7	6.1
304	1,387*	1,424	1,588	1,631	164	11.5	8.0

* b − 2 examination.
† b − 1 examination.
‡ d + 2 examination.

APPENDIX H

PROFILE ANALYSIS: NUMBER OF MAJOR PEAKS AND DIPS

Peak = Acceleration across average gain for five year span
Dip = Deceleration to zero or below

Case	*Bia-cromial*		*Bi-iliac*		*Leg Length*		*Stem Length*		*Height*		*Weight*		*Thigh Circum-ference*		*Mus-cular Strength*	
	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D
8	5	2	3	1	2	0	1	0	2	0	5	1	4	0	6	5
10	4	1	4	1	2	0	3	0	2	0	4	0	3	3	3	1
18	3	2	2	1	1	0	3	0	1	0	4	1	4	2		
24	3	2	4	2	2	0	2	0	2	0	3	1	3	4	2	2
26	4	1	1	0	2	0	1	0	1	0	1	0	4	2	2	1
30	4	0	3	1	3	1	3	1	2	0	1	1	3	2	2	2
32	3	3	3	2	3	0	1	0	1	0	2	0	3	1	5	3
34	4	1	2	1	2	0	1	0	1	0	3	1	2	2	3	1
36	3	3	3	1	4	0	2	1	1	0	4	1	5	3	5	1
40	2	1	3	1	2	0	3	0	2	0	2	1	3	3	3	1
44	2	1	2	1	2	0	2	0	2	0	3	1	3	4	4	1
50	3	0	4	0	2	0	2	0	2	0	4	2	6	3	3	2
52	3	2	3	1	3	1	1	0	2	0	2	1	3	3	4	2
54	3	2	2	1	2	0	1	1	2	0	4	1	4	5	3	1
58	3	1	3	0	3	0	3	0	1	0	3	1	4	5	3	3
60	3	1	3	0	2	0	2	0	1	0	2	1	6	4	3	1
62	3	0	2	1	2	0	2	0	1	0	2	0	2	0	1	0
64	4	0	3	1	2	0	1	0	1	0	3	0	5	2	3	1
66	4	0	4	2	3	0	3	0	2	0	3	1	3	1	3	1
68	4	1	3	1	3	0	1	0	2	0	3	0	3	0	3	1
72	3	0	2	0	1	0	3	0	2	0	2	0	4	2	4	2
74	3	1	3	0	2	0	2	0	1	0	4	1	4	3	6	4
78	4	3	3	0	2	0	1	0	1	0	4	0	5	3	1	0
80	3	1	1	1	2	0	1	1	1	0	1	0	4	3	4	2
82	4	3	4	2	2	0	2	0	2	0	4	2	4	3	4	2
84	4	2	3	0	2	0	2	0	1	0	2	0	4	2	1	0
86	4	3	1	0	3	0	2	0	1	0	2	1	5	5	5	3
88	4	1	4	1	4	0	2	0	2	0	3	0	2	3	2	2
92	3	1	3	0	2	0	2	0	1	0	2	0	4	2	2	1
96	4	4	1	1	2	0	3	0	1	0	3	0	3	2	3	2
100	4	0	3	1	3	0	1	0	1	0	1	0	4	2	4	2
104	1	0	2	0	2	0	2	0	1	0	2	0	3	2	2	0
106	3	0	2	0	2	0	2	0	2	0	2	1	2	1	2	1
108	6	3	3	0	1	0	1	1	1	0	3	0	3	2	2	1
110	4	3	4	2	2	0	2	0	3	0	4	0	5	2	3	1
112	3	1	3	0	3	0	2	0	2	0	2	0	3	2	4	3
116	4	1	3	2	2	0	1	0	2	0	3	1	2	4	1	0
120	3	2	5	2	2	0	3	0	2	0	4	1	2	2	4	2
130	3	1	2	0	3	0	1	0	2	0	2	0	3	1	4	3
134	3	2	4	0	3	0	1	0	3	0	3	2	4	2	2	1

APPENDIX H—(*Concluded*)

PROFILE ANALYSIS: NUMBER OF MAJOR PEAKS AND DIPS

Peak = Acceleration across average gain for five year span
Dip = Deceleration to zero or below

Case	*Biacromial* P	D	*Bi-iliac* P	D	*Leg Length* P	D	*Stem Length* P	D	*Height* P	D	*Weight* P	D	*Thigh Circumference* P	D	*Muscular Strength* P	D
136	4	3	4	0	3	0	2	0	1	0	3	0	4	2	4	2
144	4	1	3	0	2	0	2	0	1	0	4	1	5	4	3	1
146	2	1	3	1	1	0	2	0	1	0	3	3	3	4	2	2
150	2	0	4	2	1	0	1	0	1	0	3	1	4	2	4	2
154	5	2	3	2	2	0	1	0	2	0	3	0	4	3	4	3
164	5	0	3	1	3	0	3	1	2	0	3	1	3	3	4	3
166	3	0	2	0	3	1	3	0	2	1	2	0	5	3	2	1
168	4	1	3	0	3	0	1	0	2	0	1	0	5	4	4	3
176	4	2	2	0	3	0	4	0	2	0	3	0	4	1	5	3
180	3	2	4	0	2	0	2	0	2	0	3	1	4	3	4	2
184	4	1	3	1	2	0	2	0	1	0	3	0	3	3	5	2
190	3	3	2	0	4	0	2	0	2	0	2	0	3	2	3	2
206	4	1	2	0	4	0	2	0	2	0	3	0	3	1	5	3
212	3	1	1	0	3	1	3	0	3	0	2	0	4	1	3	2
216	5	3	3	1	2	0	2	0	1	0	3	1	3	3	4	3
218	4	2	3	2	2	1	2	0	2	0	3	0	5	2	4	1
220	4	2	2	0	3	0	1	0	3	0	2	0	3	0	3	2
224	5	2	4	4	2	0	4	1	2	0	3	2	4	3	4	1
230	3	0	2	0	3	0	2	0	1	0	2	0	4	2	2	1
234	2	0	4	0	3	0	2	0	1	0	3	0	3	2	2	0
236	5	4	4	0	3	0	3	1	2	0	3	1	4	3	6	3
242	3	1	3	2	2	1	2	0	3	0	4	1	5	4	2	0
244	4	3	3	2	2	0	2	0	1	0	3	1	4	3	4	2
250	3	2	3	2	2	0	1	1	1	0	5	2	5	4	4	3
292	3	1	2	0	2	0	2	0	1	0	2	0	4	3	4	2
294	3	1	1	0	3	0	2	0	2	0	1	0	2	1	3	1
304	3	2	3	1	2	0	1	0	1	0	2	0	3	2	2	1
Total	237	97	191	52	159	6	130	9	108	1	185	37	246	165	215	110

APPENDIX I

STEM LENGTH MEASUREMENTS IN MILLIMETERS—67 BOYS

Case Numbers	*Developmental Points* b−3	b	d	d+3	*Puberal Gain* b–d Millimeters	Per Cent	*Stem Length/Height Ratio* b−3	b	d	d+3
8	773	795	917	940	122	15.34	.522	.513	.523	.529
10	717	735	859	892	124	16.87	.515	.505	.513	.518
18	753*	769	881	903	112	14.56	.517*	.518	.515	.515
24	731	763	851	885	88	11.53	.524	.521	.519	.525
26	753†	758	904	935	146	19.26	.525†	.523	.521	.524
30	752	777	892	920	115	14.80	.508	.508	.507	.512
32	790	811	938	980	127	15.66	.506	.500	.503	.511
34	758	783	882	913	99	12.64	.503	.502	.508	.514
36	746	771	897	909	126	16.34	.497	.492	.508	.507
40	684	705	806	837	101	14.33	.514	.507	.510	.517
44	750	777	896	945	119	15.32	.536	.530	.537	.542
50	737	761	884	919	123	16.16	.488	.483	.493	.498
52	779	805	913	935	108	13.42	.509	.503	.510	.510
54	774	801	903	923	102	12.73	.511	.511	.515	.517
58	781	792	879	917	87	10.98	.525	.514	.510	.519
60	723	753	838	876	85	11.29	.524	.518	.519	.529
62	681	706	828	858	122	17.28	.512	.510	.514	.523
64	749	760	880	912	120	15.79	.520	.510	.513	.516
66	791	821	876	904	55	6.70	.520	.515	.515	.524
68	770	799	932	950	133	16.64	.521	.516	.520	.521
72	748*	774	875	906	101	13.05	.506*	.507	.500	.505
74	818†	823	955	985	132	16.04	.503†	.501	.497	.504
78	735	760	862	891	102	13.42	.502	.497	.504	.510
80	751	769	898	934	129	16.78	.518	.508	.517	.526
82	740	767	909	942	142	18.51	.527	.522	.523	.525
84	738	763	883	905	120	15.73	.502	.499	.509	.512
86	771†	777	877	892	100	12.87	.515†	.513	.503	.506
88	725	755	858	906	103	13.64	.510	.502	.506	.516
92	704	736	826	857	90	12.23	.512	.509	.511	.517
96	762	792	894	929	102	12.88	.519	.515	.515	.520
100	747	772	901	950	129	16.71	.533	.528	.531	.537
104	800*	814	907	947	93	11.42	.509*	.503	.503	.511
106	748	783	884	917	101	12.90	.505	.503	.515	.519
108	722	741	874	901	133	17.95	.517	.509	.519	.519
110	744	782	883	926	101	12.92	.524	.516	.520	.526
112	787	820	903	945	83	10.12	.519	.516	.512	.518
116	720	749	866	893	117	15.62	.541	.545	.552	.554
120	755	786	889	920	103	13.10	.511	.511	.512	.516
130	745	764	874	886‡	110	13.99	.504	.498	.499	.510‡
134	782	811	903	929	92	11.34	.506	.500	.503	.508
136	760	779	903	932	124	15.92	.536	.524	.526	.527
144	754*	771	891	939	120	15.56	.498*	.491	.489	.499
146	755	780	865	891	85	10.90	.518	.511	.509	.511

APPENDIX I—(*Concluded*)

STEM LENGTH MEASUREMENTS IN MILLIMETERS—67 BOYS

Case Numbers	*Developmental Points*				*Puberal Gain* b–d		*Stem Length/Height Ratio*			
	b−3	b	d	d+3	Milli-meters	Per Cent	b−3	b	d	d+3
150	782†	788	922	950	134	17.01	.530†	.528	.520	.525
154	750	767	867	895	100	13.04	.517	.509	.511	.516
164	740	756	893	925	137	18.12	.512	.501	.508	.515
166	738	760	894	909	134	17.63	.517	.516	.514	.514
168	787	820	960	983	140	17.07	.514	.515	.524	.531
176	794	820	900	946	80	9.76	.530	.525	.524	.533
180	725	743	883	908	140	18.84	.497	.491	.487	.495
184	752	777	910	941	133	17.12	.518	.512	.514	.522
190	724	750	855	875	105	14.00	.502	.496	.500	.503
206	726	747	858	886	111	14.86	.510	.502	.505	.509
212	708	732	850	862‡	118	16.12	.509	.504	.511	.513‡
216	758*	774	918	940	144	18.60	.534*	.529	.533	.540
218	743	759	862	876‡	103	13.57	.526	.517	.519	.523‡
220	755	773	878	892‡	105	13.58	.511	.505	.509	.511‡
224	799	813	897	916	84	10.33	.510	.499	.507	.508
230	728	750	895	918	145	19.33	.514	.507	.508	.511
234	790	819	963	978	144	17.58	.521	.520	.520	.520
236	797	816	884	903	68	8.33	.498	.492	.497	.499
242	717	741	822	864	81	10.93	.511	.504	.494	.500
244	785	797	943	953	146	18.32	.523	.517	.525	.526
250	794*	795	908	936	113	14.21	.526*	.514	.513	.519
292	765	791	893	935	102	12.90	.511	.507	.513	.519
294	760*	774	901	911	127	16.41	.531*	.526	.534	.536
304	714*	727	827	863	100	13.76	.515*	.511	.521	.529

* b − 2 examination.
† b − 1 examination.
‡ d + 2 examination.

APPENDIX J

TIME RELATION OF THE APEX OF HEIGHT, OF STEM LENGTH, AND OF LEG LENGTH—67 BOYS

Case Number	*Age Height Apex* Years	*Age Stem Length Apex* Years	*Difference Stem Length from Height* Years	*Age Leg Length Apex* Years	*Difference Leg Length from Height* Years	*Difference Leg Length from Stem Length* Years	*Average Gain per .1 Year at Stem Length Apex* Millimeters	*Average Gain per .1 Year at Leg Length Apex* Millimeters
8	13.85	13.85	0	11.95*	−1.90	−1.90	5.6	6.3
10	14.35	15.35	+1	13.85	−.50	−1.50	7.2	6.8
18	13.80	14.90	+1.10	13.80	0	−1.10	6.8	6.0
24	15.25	15.25	0	15.70	+.45	+.45	5.6	6.7
26	13.15	13.15	0	11.95	−1.20	−1.20	7.6	6.7
30	15.70	15.20	−.50	15.70	0	+.50	7.5	8.0
32	13.65	14.65	+1.00	13.65	0	−1.00	5.4	5.8
34	15.65	15.65	0	15.65	0	0	5.8	4.2
36	15.35	15.85	+.50	15.35	0	−.50	6.8	5.2
40	14.25	13.75	−.50	13.25	−1.0	−.50	7.2	7.0
44	13.35	13.35	0	13.10	−.25	−.25	6.6	4.0
50	14.35	15.85	+1.50	14.35	0	−1.50	8.0	5.6
52	15.15	16.15	+1.00	15.15	0	−1.00	4.8	7.6
54	14.90	14.90	0	13.45	−1.45	−1.45	6.8	5.0
58	15.25	14.75	−.50	15.25	0	+.50	5.0	5.4
60	14.20	14.20	0	14.20	0	0	4.7	6.3
62	14.45	14.45	0	13.95	−.50	−.50	5.8	5.0
64	14.70	13.25	−.45	14.70	0	+1.45	5.2	4.7
66	14.20	15.15	+.95	14.20	0	−.95	4.0	4.7
68	14.35	16.30	+1.95	11.85*	−2.50	−4.45	5.3	5.6
72	14.15	15.15	+1.00	14.15	0	−1.00	4.4	5.4
74	12.25	12.75	+.50	12.25	0	−.50	6.0	6.6
78	15.40	14.90	−.50	15.40	0	+.50	4.2	7.0
80	13.85	13.85	0	13.30	−.50	−.50	8.8	5.2
82	13.90	13.90	0	13.30	−.60	−.60	7.3	5.2
84	15.40	14.90	−.50	15.40	0	+.50	7.0	6.1
86	13.35	14.40	+1.05	13.35	0	−1.05	5.8	7.6
88	12.55	13.55	+1.00	12.55	0	−1.00	6.6	6.4
92	14.10	14.10	0	14.10	0	0	6.3	6.7
96	13.55	13.55	0	13.55	0	0	5.4	5.4
100	12.95	14.45	+1.50	12.95	0	−1.50	6.4	6.0
104	12.75	12.75	0	13.00	+.25	+.25	7.8	6.0
106	14.15	14.15	0	14.65	+.50	+.50	6.4	5.2
108	13.05	12.55	−.50	13.05	0	+.50	6.0	8.4
110	14.00	14.00	0	11.00*	−3.00	−3.00	8.7	6.8
112	13.15	13.65	+.50	13.15	0	−.50	5.4	8.4
116	13.25	13.75	+.50	13.25	0	−.50	6.0	5.8
120	13.95	14.40	+.45	13.95	0	−.45	6.7	6.4
130	15.60	15.60	0	16.10	+.50	+.50	5.5	4.5
134	13.90	15.50	+1.60	13.90	0	−1.60	4.7	5.7
136	14.65	13.65	−1.50	14.65	0	+1.00	6.0	5.4
144	13.25	13.25	0	13.25	0	0	6.4	7.0
146	12.70	13.65	+.95	12.70	0	−.95	5.8	7.0
150	12.75	14.35	+1.60	11.85	−.90	−2.50	5.2	5.7
154	12.90	14.40	+1.50	12.90	0	−1.50	5.8	5.5
164	14.50	14.50	0	11.55*	−2.95	−2.95	7.0	6.3
166	13.85	14.35	+.50	14.85	+1.00	+.50	8.2	6.6
168	13.85	14.35	+.50	11.85*	−2.00	−2.50	6.6	6.0
176	12.90	15.95†	+3.05	12.90	0	−3.05	4.8	5.5
180	15.05	15.05	0	14.55	−.50	−.50	7.6	5.7
184	13.85	13.85	0	13.35	−.50	−.50	8.6	6.2

APPENDIX J—(*Concluded*)

TIME RELATION OF THE APEX OF HEIGHT, OF STEM LENGTH, AND OF LEG LENGTH—67 BOYS

Case Number	*Age Height Apex* Years	*Age Stem Length Apex* Years	*Difference Stem Length from Height* Years	*Age Leg Length Apex* Years	*Difference Leg Length from Height* Years	*Difference Leg Length from Stem Length* Years	*Average Gain per .1 Year at Stem Length Apex* Millimeters	*Average Gain per .1 Year at Leg Length Apex* Millimeters
190	15.25	15.75	+.50	15.25	0	−.50	5.4	5.6
206	14.05	15.60	+1.55	10.60*	−3.45	−5.00	5.0	5.9
212	13.45	14.50	+1.05	13.95	+.50	−.55	8.2	6.6
216	12.70	12.70	0	12.00	−.70	−.70	8.8	5.6
218	15.60	16.55	+.95	15.60	0	−.95	4.3	4.8
220	15.45	15.70	+.25	12.35*	−3.10	−3.35	4.8	4.6
224	14.95	14.95	0	12.85*	−2.10	−2.10	6.2	4.8
230	13.35	14.95	+1.60	13.35	0	−1.60	5.0	6.4
234	15.15	14.65	−.50	15.15	0	+.50	7.0	5.8
236	14.40	14.40	0	10.90*	−3.50	−3.50	5.2	4.9
242	13.55	14.55	+1.00	13.55	0	−1.00	4.6	5.8
244	15.10	15.60	+.50	15.10	0	−.50	6.3	5.5
250	12.95	13.45	+.50	12.00	−.95	−1.45	5.8	6.7
292	13.65	14.15	+.50	13.65	0	−.50	6.4	5.8
294	15.15	14.65	−.50	14.15	−1.00	−.50	6.4	5.2
304	14.15	14.65	+.50	14.15	0	−.50	7.2	7.0

* Preceding onset puberal growth period.
† Following end puberal growth period.

APPENDIX K

LEG LENGTH MEASUREMENTS IN MILLIMETERS—67 BOYS

Case Numbers	*Developmental Points* b − 3	b	d	d + 3	*Puberal Gain* b–d Milli-meters	Per Cent
8	707	755	837	838	82	10.86
10	675	720	817	831	97	13.47
18	704*	716	831	849	115	16.06
24	663	704	788	801	84	11.93
26	681†	693	835	848	142	20.49
30	727	773	868	870	95	12.29
32	770	811	926	938	115	14.18
34	750	780	853	862	73	9.36
36	756	796	860	884	64	8.04
40	648	687	773	781	86	12.52
44	650	691	773	800	82	11.87
50	774	814	910	925	96	11.79
52	752	794	878	899	84	10.58
54	740	766	851	863	85	11.10
58	708	747	845	847	98	13.12
60	658	700	779	781	79	11.28
62	649	680	784	784	104	15.29
64	692	732	838	855	106	14.48
66	730	775	846	843	71	9.16
68	708	752	860	873	108	14.36
72	731*	753	876	887	123	16.33
74	807†	821	967	970	146	17.78
78	728	759	851	857	92	12.12
80	699	745	835	841	90	12.08
82	665	704	831	853	127	18.04
84	733	765	850	861	85	11.11
86	727†	738	864	891	126	17.07
88	698	721	836	851	115	15.95
92	670	710	792	813	82	11.55
96	706	745	841	857	96	12.88
100	654	690	798	820	108	15.65
104	772*	803	896	906	93	11.58
106	735	775	848	857	73	9.42
108	675	717	812	834	95	13.25
110	677	712	814	834	102	14.32
112	728	771	859	881	88	11.41
116	612	626	704	718	78	12.46
120	722	751	848	862	97	12.92
130	734	771	864	872‡	93	12.06
134	763	810	894	901	84	10.37
136	658	707	815	838	108	15.28
144	761*	799	933	943	134	16.77
146	702	746	835	852	89	11.93

APPENDIX K—(*Concluded*)

LEG LENGTH MEASUREMENTS IN MILLIMETERS—67 BOYS

Case Numbers	*Developmental Points* b − 3	b	d	d + 3	*Puberal Gain* b–d Millimeters	Per Cent
150	693†	705	854	860	149	21.13
154	700	741	831	839	90	12.14
164	705	752	866	874	114	15.16
166	677	725	851	859	126	17.38
168	743	773	874	874	101	13.06
176	703	741	816	830	75	10.12
180	733	770	929	929	159	20.65
184	701	743	859	862	116	15.63
190	717	763	856	865	93	12.19
206	704	737	840	854	103	13.89
212	683	723	821	821‡	98	13.55
216	662*	683	805	805	122	17.86
218	669	706	799	799‡	93	13.17
220	723	756	847	852‡	91	12.04
224	767	814	876	887	62	7.62
230	688	730	869	878	139	19.04
234	727	758	889	904	131	17.28
236	802	843	896	907	53	6.29
242	686	731	840	863	109	14.91
244	716	747	857	865	110	14.72
250	716*	754	863	868	109	14.46
292	733	770	849	865	79	10.26
294	672*	697	787	791	90	12.91
304	673*	697	761	768	64	9.18

* b − 2 examination.
† b − 1 examination.
‡ d + 2 examination.

APPENDIX L

BIACROMIAL WIDTH MEASUREMENTS IN MILLIMETERS—67 BOYS

Case Numbers	*Developmental Points* b − 3	b	d	d + 3	*Final Exami- nation*	*Puberal Gain* b–d Milli- meter	Per Cent
8	312	333	384	390	409	51	15.31
10	300	322	377	404	412	55	17.08
18	275*	316	379	394	400	63	19.93
24	280	305	345	363	363	40	13.11
26	322†	322	384	402	438	62	19.25
30	295	303	357	375	375	54	17.82
32	309	316	370	399	409	54	17.08
34	314	322	365	385	385	43	13.35
36	303	303	353	372	372	53	17.66
40	273	285	333	355	361	52	18.24
44	306	312	362	386	386	50	16.02
50	305	325	372	384	387	47	14.46
52	318	322	378	387	387	56	17.39
54	315	320	358	362	383	38	11.87
58	305	305	343	361	365	42	13.95
60	310	333	375	382	400	42	12.61
62	292	311	375	398	398	64	20.57
64	292	313	366	372	384	53	16.93
66	326	350	382	394	401	32	9.14
68	308	325	371	396	396	46	14.15
72	320*	321	374	385	396	53	16.51
74	349†	350	425	445	463	75	21.42
78	286	286	336	355	367	53	18.72
80	296	318	375	384	388	57	17.92
82	275	282	341	379	382	59	20.92
84	304	324	381	385	395	57	17.59
86	292†	304	361	376	398	57	18.75
88	287	315	368	381	384	53	16.82
92	289	295	346	358	370	51	17.28
96	301	314	352	370	386	38	12.10
100	292	306	362	391	406	56	18.30
104	304*	325	373	382	402	48	14.76
106	323	344	377	402	414	33	9.59
108	295	309	363	389	395	54	17.47
110	303	309	353	389	396	44	14.23
112	309	315	365	379	395	50	15.87
116	308	317	362	379	393	45	14.19
120	295	317	359	380	388	42	13.24
130	311	319	358			39	12.22
134	309	318	356	369	376	38	11.94
136	288	304	361	377	379	57	18.75
144	310*	326	385	412	431	59	18.09

APPENDIX L—*(Concluded)*

BIACROMIAL WIDTH MEASUREMENTS IN MILLIMETERS—67 BOYS

Case Numbers	*Developmental Points* b − 3	b	d	d + 3	*Final Exami-nation*	*Puberal Gain* b–d Milli-meter	Per Cent
146	317	329	374	391	407	45	13.67
150	300†	312	392	404	417	80	25.64
154	304	312	357	380	395	35	11.21
164	293	315	372	395	403	57	18.09
166	316	322	397	412	412	75	23.29
168	307	337	405	417	422	68	20.17
176	313	332	364	383	396	32	9.63
180	312	327	399	410	410	72	22.01
184	312	328	380	390	391	52	15.85
190	300	313	363	375	375	50	15.97
206	305	322	385	397	397	63	19.56
212	285	315	371	380‡	380	56	17.77
216	315*	327	396	408	414	69	21.10
218	311	319	371	377‡	377	52	16.30
220	305	325	375	392‡	392	50	15.38
224	338	346	386	404	406	40	11.56
230	306	311	372	385	388	61	19.61
234	317	332	404	417	417	72	21.68
236	363	369	394	413	417	25	6.77
242	296	316	371	390	402	55	17.40
244	282	293	337	365	365	44	15.01
250	315*	315	368	381	402	53	16.82
292	326	339	386	408	417	47	13.86
294	300*	306	358	358	358	53	17.32
304	287*	292	336	355	363	44	15.06

* b − 2 examination.
† b − 1 examination.
‡ d + 2 examination.

APPENDIX M

TIME RELATION OF APEX BIACROMIAL AND APEX BI-ILIAC TO APEX HEIGHT

Case Number	*Biacromial Apex Average Gain per .1 Year* Millimeter	*Age Biacromial Apex* Years	*Bi-iliac Apex Average Gain per .1 Year* Millimeter	*Age Bi-iliac Apex* Years	*Years Difference Biacromial from Height*	*Years Difference Bi-iliac from Height*	*Years Difference Biacromial from Bi-illac*
8	5.0	14.35	2.0	11.95*	+1.50	−1.90	+2.40
10	3.4	13.85	2.0	16.30†	−.50	+1.95	−2.45
18	4.3	11.00*	1.7	11.75	−2.80	−2.05	−.75
24	4.0	14.20	2.0	11.75*	−1.05	−3.50	+2.45
26	5.5	16.20†	2.5	13.70	+3.05†	+.55	+2.50†
30	3.0	16.20	3.5	15.70	+.50	0	+.50
32	3.8	15.60†	2.2	13.65	+1.95	0	+1.95
34	4.0	15.15	2.0	14.15	−.50	−1.50	+1.00
36	4.0	14.85	2.3	11.10*	−.50	−4.25	+3.75
40	2.8	13.75	1.8	14.25	−.50	0	−.50
44	6.0	14.35	1.8	14.35	+1.00	+1.00	0
50	3.8	15.35	1.8	15.35	+1.00	+1.00	0
52	3.3	11.60*	2.6	15.65	−3.55	+.50	−4.05
54	3.0	14.90	1.8	13.90	0	−1.0	+1.00
58	4.0	13.75	2.0	15.25	−1.50	0	−1.50
60	4.5	12.10*	2.0	14.20	−2.10	0	−2.10
62	3.2	14.45	2.2	14.45	0	0	0
64	3.0	11.70*	2.5	14.70	−3.00	0	−3.00
66	4.7	15.15	3.8	14.20	+.95	0	+.95
68	3.7	11.85*	1.6	14.85	−2.50	+.50	−3.00
72	3.6	14.15	2.5	11.60*	0	−2.55	+2.55
74	5.0	11.20	3.4	13.75	−1.05	+1.50	−2.55
78	4.0	16.40	2.2	12.90*	+1.00	−2.50	+3.50
80	5.5	11.80*	2.8	13.85	−2.05	0	−2.05
82	4.8	14.50	3.0	13.90	+.60	0	+.60
84	4.4	13.45*	1.8	15.95	−1.95	+.50	−2.50
86	4.0	11.90	1.8	13.90	−1.45	+.55	−2.00
88	4.4	12.55	2.2	12.55	0	0	0
92	5.3	14.10	2.8	14.10	0	0	0
96	2.6	14.05	1.8	13.55	+.50	0	+.50
100	4.0	15.55†	2.6	12.95	+2.60	0	+2.60
104	3.2	11.75	2.5	11.20*	−1.00	−1.55*	+.55
106	3.6	15.15	2.4	14.65	+1.00	+.50	+.50
108	7.2	13.05	2.4	13.05	0	0	0
110	6.0	15.55†	2.6	13.55	+1.55	−.45	+2.00
112	3.2	13.15	1.7	14.80	0	+1.65	−1.65
116	3.0	14.75	2.4	14.25	+1.50	+1.00	+.50
120	5.2	14.40	3.0	10.90*	+.45	−3.05	+3.50
130	3.6	16.55	1.9	15.60	+.95	0	+.95
134	2.4	14.95	1.8	14.45	+1.05	+.55	+.50
136	2.6	15.15	2.0	13.20	−.50	−1.45	+1.95
144	3.8	13.25	2.0	13.25	0	0	0
146	6.2	13.65	2.0	12.70	+.95	0	+.95
150	4.0	13.85	2.3	11.85	+1.10	−.90	+2.00
154	3.6	15.95†	2.0	11.45*	+3.05	−1.45	+4.50
164	4.3	15.50†	2.0	16.00†	+1.00	+1.50	−.50
166	3.8	13.35	2.0	15.85	−.50	+2.00	−2.50
168	5.0	11.85*	2.2	13.85	−2.00	0	−2.00

APPENDIX M—(*Concluded*)

TIME RELATION OF APEX BIACROMIAL AND APEX BI-ILIAC TO APEX HEIGHT

Case Number	*Biacromial Apex Average Gain per .1 Year* Millimeter	*Age Biacromial Apex* Years	*Bi-iliac Apex Average Gain per .1 Year* Millimeter	*Age Bi-iliac Apex* Years	*Years Difference Biacromial from Height*	*Years Difference Bi-iliac from Height*	*Years Difference Biacromial from Bi-iliac*
176	3.8	14.80	1.8	12.90	+1.90	0	+1.90
180	3.6	16.05	2.8	15.05	+1.00	0	+1.00
184	4.0	13.35	2.0	11.80†	−.50	−2.05	+1.55
190	4.2	16.25	1.6	15.25	+1.00	0	+1.00
206	3.2	14.55	2.0	15.60	+.50	+1.55	−1.05
212	3.2	13.45	2.0	13.95	0	+.50	−.50
216	3.7	13.70	3.0	11.25	+1.00	−1.45	+2.45
218	4.2	16.10	2.5	16.10	+.50	+.50	0
220	3.4	15.45	1.8	15.95	0	+.50	−.50
224	4.0	15.45	1.8	12.35*	+.50	−2.60	+2.90
230	4.0	12.85	2.2	15.95†	−.50	+2.60	−3.10
234	4.0	15.90	2.4	14.15	+.75	−1.00	+1.75
236	4.8	16.40†	1.8	12.40*	+2.00	−2.00	+4.00
242	3.4	13.80	1.8	13.55	+.25	0	+.25
244	5.3	15.60	2.8	15.10	+.50	0	+.50
250	4.5	12.00	2.6	11.55	−.95	−1.40	+.45
292	4.2	12.15*	2.2	14.15	−1.50	+.50	−2.0
294	2.6	13.65	2.2	14.90	−1.50	−.25	−1.25
304	4.4	15.15	1.6	14.65	+1.00	+.50	+.50

* Preceding onset puberal growth period.
† Following end puberal growth period.

APPENDIX N

BI-ILIAC WIDTH MEASUREMENTS IN MILLIMETERS—67 BOYS

Case Number	*Bi-iliac Measurements at Developmental Points* b−3	b	d	d+3	Final Examination	*Puberal Gain* b–d	*Biacromial/Bi-iliac Ratio* b−3	b	d	d+3	Final Examination
8	236	244	276	285	287	32	1.36	1.36	1.39	1.37	1.43
10	214	223	250	263	267	27	1.40	1.44	1.52	1.54	1.54
18	225*	229	261	264	265	32	1.22*	1.38	1.45	1.49	1.51
24	216	232	251	265	265	19	1.30	1.31	1.37	1.37	1.37
26	229†	232	287	292	296	55	1.41†	1.38	1.34	1.38	1.48
30	214	227	262	273	273	35	1.38	1.34	1.36	1.37	1.37
32	218	233	267	275	276	34	1.49	1.35	1.39	1.45	1.48
34	231	239	272	279	279	33	1.36	1.35	1.34	1.38	1.38
36	239	247	278	282	282	31	1.27	1.21	1.25	1.32	1.32
40	208	214	249	249	256	35	1.41	1.34	1.34	1.44	1.41
44	226	236	265	272	272	29	1.35	1.31	1.37	1.42	1.44
50	234	246	275	286	286	29	1.30	1.32	1.35	1.34	1.36
52	240	247	280	286	286	33	1.33	1.30	1.35	1.35	1.35
54	238	241	271	280	280	30	1.32	1.32	1.32	1.29	1.37
58	231	235	264	274	274	29	1.32	1.28	1.29	1.32	1.33
60	223	235	263	269	273	28	1.39	1.42	1.43	1.42	1.47
62	211	220	259	268	271	39	1.38	1.41	1.44	1.49	1.45
64	212	223	254	263	266	31	1.38	1.41	1.47	1.41	1.44
66	258	274	293	293	293	19	1.26	1.29	1.27	1.37	1.40
68	240	248	288	290	290	40	1.28	1.31	1.29	1.37	1.37
72	211*	228	263	271	275	35	1.52*	1.41	1.42	1.42	1.44
74	269†	270	314	325	326	44	1.30†	1.30	1.35	1.37	1.42
78	212	231	262	269	270	31	1.35	1.22	1.28	1.32	1.36
80	226	231	270	278	278	39	1.31	1.38	1.39	1.38	1.42
82	212	230	269	279	279	39	1.30	1.22	1.27	1.36	1.39
84	226	236	268	274	276	32	1.35	1.37	1.42	1.41	1.43
86	219†	221	257	264	267	36	1.33†	1.37	1.40	1.42	1.49
88	249	253	291	302	304	38	1.19	1.25	1.27	1.26	1.26
92	210	221	249	258	261	28	1.38	1.33	1.39	1.39	1.42
96	219	225	256	263	265	31	1.37	1.40	1.38	1.41	1.46
100	221	232	272	286	290	40	1.32	1.32	1.33	1.37	1.40
104	231*	249	272	276	283	23	1.32*	1.30	1.37	1.38	1.42
106	240	251	281	288	291	30	1.35	1.37	1.34	1.40	1.42
108	235	244	283	294	297	39	1.26	1.26	1.28	1.32	1.33
110	216	231	261	273	280	30	1.40	1.34	1.35	1.42	1.41
112	235	248	270	278	286	22	1.31	1.27	1.35	1.36	1.38
116	215	222	257	268	268	35	1.43	1.43	1.40	1.41	1.48
120	231	240	271	278	281	31	1.28	1.32	1.32	1.39	1.38
130	232	241	267			26	1.34	1.34	1.34		
134	246	255	290	296	296	35	1.26	1.24	1.24	1.25	1.27
136	225	237	278	291	291	41	1.28	1.28	1.32	1.30	1.31
144	231*	239	273	285	288	34	1.34*	1.36	1.41	1.45	1.50
146	246	257	282	295	300	25	1.29	1.28	1.32	1.33	1.36
150	236†	236	271	280	281	35	1.27	1.33	1.44	1.44	1.48
154	215	228	257	263	266	29	1.41	1.36	1.39	1.44	1.48
164	236	246	286	295	298	40	1.24	1.28	1.30	1.34	1.35
166	222	230	266	271	271	36	1.42	1.40	1.49	1.52	1.52
168	238	248	290	296	298	42	1.29	1.39	1.40	1.41	1.42
176	235	243	272	283	286	29	1.33	1.36	1.34	1.35	1.38
180	226	237	286	291	291	49	1.38	1.38	1.40	1.41	1.41
184	221	236	271	277	278	35	1.41	1.39	1.40	1.41	1.41
190	222	231	265	271	271	34	1.35*	1.35	1.36	1.38	1.38
206	223	232	271	278	278	39	1.37	1.39	1.40	1.43	1.43
212	222	234	276	281‡	281	42	1.28	1.34	1.35	1.35‡	1.35
216	234*	247	279	288	288	32	1.35*	1.33	1.42	1.42	1.45
218	225	234	271	271‡	271	37	1.38	1.36	1.36	1.39‡	1.39
220	230	241	274	277‡	277	33	1.33	1.34	1.36	1.42‡	1.42

APPENDIX N—(*Concluded*)

BI-ILIAC WIDTH MEASUREMENTS IN MILLIMETERS—67 BOYS

	Bi-iliac Measurements at Developmental Points					*Puberal Gain*	*Biacromial/Bi-iliac Ratio*				
Case Number	b−3	b	d	d+3	Final Examination	b–d	b−3	b	d	d+3	Final Examination
224	263	274	289	291	294	15	1.29	1.26	1.32	1.39	1.38
230	221	226	269	278	278	43	1.38	1.36	1.38	1.38	1.40
234	221	235	275	280	280	40	1.43	1.41	1.46	1.49	1.50
236	258	266	286	294	294	20	1.41	1.38	1.41	1.40	1.42
242	217	223	256	266	275	30	1.36	1.41	1.45	1.49	1.46
244	224	234	274	274	274	40	1.26	1.25	1.23	1.33	1.33
250	249*	255	283	288	294	28	1.27*	1.24	1.30	1.32	1.37
292	250	260	293	308	311	33	1.30	1.30	1.32	1.32	1.34
294*	233	236	275	277	277	39	1.29*	1.30	1.30	1.28	1.28
304*	209	219	245	249	259	26	1.37*	1.33	1.37	1.43	1.40

* b − 2 examination.
† b − 1 examination.
‡ d + 2 examination.

APPENDIX O

SEQUENCES OF APEXES OF GROWTH IN HEIGHT, STEM LENGTH, LEG LENGTH, BIACROMIAL WIDTH, BI-ILIAC WIDTH 67 CASES—BOYS

		Case Numbers	Number of Cases
Group I	Apexes at 1 point	92, 144	2
Group II	Apexes at 2 points		8

Pattern	Point 1	Point 2	Case Numbers
A:	Ht., LL., Bi-il.	S.L., Bi-ac.	146, 244, 66
B:	Ht., S.L., L.L., Bi-il.	Bi-ac.	96
C:	L.L.	Ht., S.L., Bi-ac., Bi-il.	62
D:	Bi-ac.	Ht., S.L., L.L., Bi-il.	60
E:	S.L.	Ht., L.L., Bi-ac., Bi-il.	108
F:	Ht., L.L., Bi-ac., Bi-il.	S.L.	88

		Number of Cases
Group III	Apexes at 3 points	28

Pattern	Point 1	Point 2	Point 3	Case Numbers
A:	Ht., S.L.	L.L., Bi-il.	Bi-ac.	106
B:	Ht., L.L., Bi-ac.	S.L.	Bi-il.	112
C:	Ht., S.L., Bi-il.	L.L.	Bi-ac.	130
D:	Ht., L.L., Bi-il.	Bi-ac.	S.L.	176, 242
E:	Ht., L.L., Bi-il.	S.L.	Bi-ac.	32, 100, 190
F:	Ht., L.L.	Bi-ac., Bi-il.	S.L.	50, 218
G:	S.L.	Ht., L.L., Bi-il.	Bi-ac.	30
H:	L.L., Bi-ac.	Ht., Bi-il.	S.L.	168
I:	L.L.	Ht., S.L., Bi-il.	Bi-ac.	82, 180
J:	L.L., Bi-il.	Ht., S.L.	Bi-ac.	8
K:	L.L.	S.L., Bi-ac.	Ht., Bi-il.	40
L:	Bi-ac.	Ht., L.L.	S.L., Bi-il.	292
M:	Bi-ac.	S.L.	Ht., L.L., Bi-il.	58, 64
N:	Bi-ac.	L.L.	Ht., S.L., Bi-il.	80
O:	Bi-il.	Ht., L.L.	S.L., Bi-ac.	120
P:	Bi-il.	Ht., S.L., L.L.	Bi-ac.	34
Q:	Bi-il.	Ht., L.L., Bi-ac.	S.L.	72
R:	Bi-il.	L.L., Bi-ac.	Ht., S.L.	184
S:	L.L.	Ht., S.L.	Bi-ac., Bi-il.	44
T:	Ht., Bi-ac.	L.L., Bi-il.	S.L.	212
U:	Ht., L.L.	S.L., Bi-il.	Bi-ac.	304
V:	L.L.	Bi-il.	Ht., S.L., Bi-ac.	54

APPENDIX O—(*Concluded*)

SEQUENCES OF APEXES OF GROWTH IN HEIGHT, STEM LENGTH, LEG LENGTH, BIACROMIAL WIDTH, BI-ILIAC WIDTH 67 CASES—BOYS

Group IV Apexes at 4 points					*Case Numbers*	*Number of Cases*
						27
Pattern	*Point 1*	*Point 2*	*Point 3*	*Point 4*		
A:	Ht., L.L.	S.L.	Bi-il.	Bi-ac.	116	
B:	Ht., L.L.	Bi-il.	Bi-ac.	S.L.	134	
C:	L.L., Bi-ac.	S.L.	Ht.	Bi-il.	10	
D:	L.L., Bi-ac.	Ht.	Bi-il.	S.L.	68	
E:	L.L.	Bi-il.	Ht., S.L.	Bi-ac.	110, 236	
F:	L.L.	Ht., S.L.	Bi-ac.	Bi-il.	164	
G:	L.L.	Ht.	Bi-ac.	S.L., Bi-il.	206	
H:	L.L.	Ht., Bi-ac.	S.L.	Bi-il.	220	
I:	Bi-ac.	Bi-il.	Ht., L.L.	S.L.	18	
J:	Bi-ac.	Ht., L.L.	Bi-il.	S.L.	52, 86	
K:	Bi-ac.	Ht., L.L.	S.L.	Bi-il.	74, 230	
L:	Bi-ac.	S.L.	Ht., L.L.	Bi-il.	84	
M:	Bi-il.	Bi-ac.	Ht., S.L.	L.L.	24, 104	
N:	Bi-il.	S.L.	Ht., L.L.	Bi-ac.	78, 136, 234	
O:	Bi-il.	Ht., L.L.	S.L.	Bi-ac.	154	
P:	Bi-il.	L.L.	Ht., S.L.	Bi-ac	216, 224	
Q:	Bi-il.	L.L., Bi-ac.	Ht.	S.L.	250	
R:	Bi-il.	Bi-ac.	Ht., L.L.	S.L.	36	
S:	L.L.	Ht., S.L.	Bi-il.	Bi-ac.	26	
T:	L.L., Bi-il.	Ht.	Bi-ac.	S.L.	150	

Group V Apexes at 5 points							2
Pattern	*Point 1*	*Point 2*	*Point 3*	*Point 4*	*Point 5*		
A:	Bi-ac.	Ht.	S.L.	L.L.	Bi-il.	166	
B:	Bi-ac.	L.L.	S.L.	Bi-il.	Ht.	294	

APPENDIX P

SKELETAL AGE RATINGS AT DEVELOPMENTAL POINTS—67 BOYS

Case Number	b	c	d	d+3
8			35.00	38.00
10			32.75	35.75
18			33.75	35.25
24			31.75	34.00
26			33.75	36.00
30	29.00	31.00	34.50	37.00
32			33.75	35.25
34	31.00	32.50	34.50	38.00
36	28.75	31.75	34.25	37.00
40		30.00	33.00	36.00
44			32.50	35.00
50		31.75	33.50	36.50
52		30.50	33.75	37.00
54		30.50	33.50	36.50
58			33.75	37.00
60			33.00	35.25
62			33.50	35.75
64			33.25	35.00
66			33.00	35.50
68		31.25	33.75	35.75
72			32.00	34.00
74			34.75	36.00
78			33.50	35.50
80			34.00	36.50
82			33.50	34.00
84			33.25	35.50
86			33.75	35.50
88			32.25	34.50
92			32.25	35.50
96			33.50	35.25
100		29.50	31.50	34.75
104			33.25	35.25
106			33.25	35.00
108		29.50	31.75	35.00
110		29.50	31.50	35.00
112			32.50	35.50
116		30.00	33.00	36.00
120		31.00	33.75	36.00
130	29.00	31.50	34.25	
134	28.25	30.25	33.00	35.50
136		29.50	32.00	34.50
144			33.50	35.50
146			33.00	35.50
150			34.00	36.00
154		30.50	33.00	35.00

APPENDIX P—(*Concluded*)

SKELETAL AGE RATINGS AT DEVELOPMENTAL POINTS—67 BOYS

Case Number	b	c	d	d+3
164		29.50	33.75	35.25
166		29.50	33.50	36.00
168		31.50	35.00	38.00
176		29.25	31.25	34.50
180		29.00	34.25	36.00
184		29.50	34.50	37.25
190	28.75	30.00	34.00	36.50
206	27.00	29.75	33.00	36.00
212		29.50	33.50	35.75‡
216			35.00	38.00
218	28.75	32.00	35.25	37.50‡
220	29.25	31.00	34.00	36.75‡
224	30.00	32.00	34.50	37.50
230		29.50	33.50	35.50
234		30.00	34.00	36.00
236	30.00	31.75	33.00	35.50
242			31.25	34.75
244			33.50	37.00
250			35.00	36.50
292		31.50	33.00	35.00
294			35.00	38.75
304			32.25	34.75

‡ d + 2 examination.

APPENDIX Q

SUBCUTANEOUS TISSUE INDEX—67 BOYS

Cases	*First Examination*	*b*	*Difference First Examination and b*	*d*	*Difference b–d*	*Last Examination*	*Difference d–Last*	*b−3*	*Difference b−3 and b*	*d+3*	*Difference d– d+3*
8	37	47	+10	43	−4	52	+9	37	+10	44	+1
10	34	48	+14	42	−6	43	+1	34	+14	42	0
18	36	51	+15	44	−7	63	+19	36*	+15	52	+8
24	43	56	+13	39	−17	43	+4	56	0	43	+4
26	37	37	0	40	+3	39	−1	37†	0	38	−2
30	31	47	+16	45	−2	43	−2	42	+5	43	−2
32	44	44	0	37	−7	47	+10	44	0	39	+2
34	29	40	+11	41	+1	43	+2	35	+5	43	+2
36	58	67	+9	63	−4	63	0	58	+9	63	0
40	38	37	−1	39	+2	44	+5	40	−3	46	+7
44	40	53	+13	36	−17	38	+2	40	+13	38	+2
50	41	51	+10	41	−10	48	+7	47	+4	48	+7
52	34	40	+6	38	−2	43	+5	45	−5	43	+5
54	59	54	−5	44	−10	40	−4	59	−5	45	+1
58	52	65	+13	53	−12	54	+1	66	−1	51	−2
60	29	39	+10	35	−4	37	+2	29	+10	31	−4
62	33	40	+7	42	+2	41	−1	33	−1	41	−1
64	38	52	+14	43	−9	44	+1	38	+14	44	+1
66	67	88	+21	89	+1	88	−1	79	+9	70	−19
68	33	37	+4	37	0	43	+6	39	−2	43	+6
72	36	39	+3	42	+3	47	+5	36*	+3	41	−1
74	72	73	+1	44	−29	49	+5	72†	+1	56	+14
78	43	47	+4	40	−7	45	+5	43	+4	45	+5
80	33	42	+9	47	+5	39	−8	33	+9	45	−2
82	61	70	+9	66	−4	61	−5	61	+9	64	−2
84	34	57	+13	49	−8	56	+7	49	+8	56	+7
86	43	46	+3	59	+13	47	−12	43†	+3	44	+15
88	48	64	+16	49	−15	63	+14	63	+1	56	+7
92	37	42	+5	37	−5	36	−1	34	+8	40	+3
96	36	37	+1	33	−4	41	+8	36	+1	33	0
100	33	40	+7	38	−2	39	+1	34	+6	45	+7
104	58	58	0	45	−13	54	+9	58*	0	49	+4
106	42	46	+4	41	−5	43	+2	49	−3	45	+4
108	49	44	−5	46	+2	44	−2	44	0	43	−3
110	44	44	0	42	−2	52	+10	46	−2	41	−1
112	36	38	+2	37	−1	43	+6	43	−5	41	+4
116	37	37	0	40	+3	49	+9	37	0	53	+13
120	55	56	+1	49	−7	45	−4	55	+1	51	+2
130	37	44	+7	40	−4	39	−1	47	−3	39	−1
134	45	41	−4	34	−7	40	+6	44	−3	40	+6
136	34	42	+8	36	−6	39	+3	40	+2	39‡	+3
144	40	45	+5	43	−2	42	−1	40*	+5	38	−5
146	67	65	−2	70	+3	50	−20	67	−2	48	−22
150	49	47	−2	42	−7	55	+7	49†	−2	52	−10
154	37	42	+5	42	0	45	+3	46	−4	41	−1
164	48	59	+11	45	−14	54	+9	48	+11	52	+7
166	38	42	+4	49	+7	45	−4	41	+1	45	−4
168	34	36	+2	37	+1	40	+3	34	+2	37	0
176	42	38	−4	39	+1	44	+5	39	−1	37	−2
180	40	44	+4	40	−4	41	+1	36	+8	41	+1
184	40	53	+13	45	−8	40	−5	39	+14	40	−5
190	33	35	+2	37	+2	40	+3	36	−1	40	+3
206	37	36	−2	41	+5	43	+3	36	0	43	+2
212	42	50	+8	48	−2	53	+5	51	−1	53‡	+5
216	57	66	+9	57	−9	71	+14	57*	+15	57	0
218	44	57	+13	59	+2	63	+4	49	+8	63‡	+4
220	36	41	+5	42	+1	37	−5	36	+5	37‡	−5

APPENDIX Q—(*Concluded*)

SUBCUTANEOUS TISSUE INDEX—67 BOYS

Cases	*First Examination*	*b*	*Difference First Examination and b*	*d*	*Difference b-d*	*Last Examination*	*Difference d-Last*	*b—3*	*Difference b—3 and b*	*d+3*	*Difference d-d+3*
224	67	53	−14	48	−5	49	+1	82	−29	49	+1
230	36	38	+2	39	+1	44	+5	41	−3	44	+5
234	45	57	+12	43	−14	48	+5	42	+15	48	+5
236	39	43	+4	38	−5	46	+8	62	−19	46	+8
242	45	52	+7	49	−3	54	+5	45	+7	48	−1
244	40	44	+4	46	+2	58	+8	43	+1	58	+12
250	66	69	+3	41	−28	43	+2	66*	+3	39	−2
292	43	50	+7	42	−8	45	+3	43	+7	54	+12
294	45	42	−3	45	+3	48	+3	45*	−3	48	+3
304	44	51	+7	45	−6	54	+9	44*	+7	45	0

* b — 2 examination.
† b — 1 examination.
‡ b + 2 examination.

APPENDIX R

THIGH CIRCUMFERENCE MEASUREMENTS—67 BOYS

Case Numbers	*Measurements Millimeters* b − 3	b	d	d + 3	*Pubertal Gain* b − d Millimeters	C.A. Apex Years	*Difference in Thigh Apex in Years from* Height Apex	Stem Length Apex	Leg Length Apex	Weight Apex
8	411	450	527	555	77	11.95	−1.90	−1.90	0	0
10	410	441	505	547	106	16.80	+2.45	+1.45	+2.95	+.50
18	420*	452	522	557	70	14.90	+1.10	0	+1.10	+1.35
24	417	443	465	462	22	14.70	−.55	−.55	−1.30	0
26	397†	400	488	498	88	14.65	+1.50	+1.50	+2.70	0
30	389	409	481	495‡	60	11.20	−4.50	−4.00	−4.65	−4.50
32	387	411	468	493	82	13.10	−.50	−1.55	−.55	0
34	418	441	503	505‡	67	11.15	−4.50	−4.50	−4.50	−4.00
36	486	513	544	560	31	15.85	+.50	0	+.50	0
40	412	413	495	508	82	11.25	−3.00	−2.50	−2.00	−3.50
44	422	450	465	495	15	14.35	+1.00	+1.00	+1.25	0
50	412	456	492	500	36	13.85	− 50	−2.00	−.50	−1.50
52	425	417	481	498	62	14.65	−.50	−1.50	−.50	−1.00
54	433	436	478	498	42	15.90	+1.00	+1.00	+2.45	0
58	435	436	502	520	66	16.35	+1.10	+1.60	+1.10	−1.00
60	389	413	454	440	40	17.65	+3.45	+3.45	+3.05	+3.45
62	369	389	463	486	74	16.50	+2.05	+2.05	+2.55	+2.05
64	410	435	486	502	51	14.70	0	+1.45	0	0
66	549	584	615	598	31	14.20	0	−.50	0	0
68	412	425	508	538	83	17.80	+3.45	+1.50	+5.95	0
72	402*	412	464	483	51	15.15	+1.00	0	+1.00	+1.00
74	525†	512	557	582	44	13.75	+1.50	+1.00	+1.50	0
78	417	426	495	522	69	16.40	+1.00	+1.50	+1.00	0
80	377	401	508	515	106	12.80	−1.05	−1.05	−.50	0
82	451	466	549	542	83	11.20	−2.70	−2.70	−2.10	−2.10
84	382	426	500	526	100	12.95	−2.45	−1.95	−2.45	−1.50
86	409†	417	471	490	54	13.90	+.55	−.50	+.55	0
88	446	462	495	530	12	12.05	−.50	−1.50	−.50	−3.50
92	357	384	428	446	49	15.05	+.95	+.95	+.95	0
96	385	408	454	475	53	13.55	0	0	0	−.50
100	358	373	453	478	80	12.95	0	−1.50	0	0
104	473*	484	525	517	41	12.75	0	0	−.25	−.50
106	428	459	496	511	38	13.60	−.55	−.55	−1.05	−1.05
108	405	421	475	485	54	16.20	+3.15	+3.65	+3.15	+2.05
110	430	444	484	511	40	15.05	+1.05	+1.05	+4.05	+1.50
112	412	430	475	512	45	13.15	0	−.50	0	0
116	409	421	498	527	77	14.25	+1.00	+.50	+1.00	0
120	448	472	539	528	67	14.40	+.45	0	+.45	0
130	415	421	470		49	12.50	−3.10	−3.10	−3.60	−3.60
134	392	427	468	485	41	12.40	−1.50	−3.10	−1.50	−2.05
136	400	408	467	473	59	11.15	−3.50	−2.50	−3.50	−4.00
144	408*	433	476	512	43	14.75	−1.50	+1.50	+1.50	0
146	470	467	488	483	21	12.20	−.50	−1.45	−.50	−2.00
150	443†	449	523	545	74	12.25	−.50	−2.10	+.40	0
154	413	451	466	476	15	11.45	−1.45	−2.95	−1.45	−3.40
164	430	438	467	482	29	15.50	+1.00	+1.00	+3.90	+2.55
166	400	422	512	523	90	14.35	+.50	0	−.50	−1.50
168	428	424	514	530	90	11.85	−2.00	−2.50	0	−1.45
176	395	417	462	477	45	14.40	+1.50	−1.45	+1.50	−.50
180	364	385	450	477	66	14.80	−.25	−.45	+.25	−.25

APPENDIX R—(*Concluded*)

THIGH CIRCUMFERENCE MEASUREMENTS—67 BOYS

Case Numbers	*Measurements Millimeters* b − 3	b	d	d + 3	*Puberal Gain* b − d Millimeters	C.A. Apex Years	*Difference in Thigh Apex in Years from* Height Apex	Stem Length Apex	Leg Length Apex	Weight Apex
184	418	462	495	495	33	11.35	−2.50	−1.50	−2.00	−2.50
190	375	396	459	474	63	15.75	+.50	0	+.50	+1.00
206	386	412	469	479	72	13.55	−.50	−2.05	+2.95	0
212	410	430	510	513‡	80	13.00	−.45	−1.50	−.95	−.45
216	471*	497	562	575	65	11.25	−1.45	−1.45	−.75	0
218	445	469	537	550‡	70	16.10	+.50	−.45	+.50	0
220	388	401	474	473‡	73	14.90	−.55	−.80	+2.45	−.55
224	575	547	579	547	32	11.45	−3.50	−3.50	−1.40	0
230	381	394	478	483	78	14.95	+1.60	0	+1.60	−1.00
234	390	439	536	540	97	15.65	+.50	+1.00	+.50	+.50
236	507	491	497	530	6	16.85	−3.50	−3.50	0	−.95
242	395	402	459	480	57	12.55	−1.00	−2.00	+2.00	−2.50
244	418	441	507	525	66	13.15	−1.95	−2.45	−1.95	−2.45
250	474*	492	501	509	9	12.00	−.95	−1.45	0	−1.45
292	433	467	524	539	57	14.65	+1.00	+.50	+1.00	+.50
294	433*	443	532	535	90	14.65	−.50	0	+.50	0
304	443*	452	519	532	67	13.65	−.50	−1.00	+.50	0

* b − 2 examination.
† b − 1 examination.
‡ d + 2 examination.

APPENDIX S

MEASUREMENTS AND TIMING OF WEIGHT GROWTH—67 BOYS

Measurements in Tenths of Kilograms

Case Numbers	b − 3	Onset (b)	End (d)	d + 3	Gain b–d	Average Gain per .1 Year Weight Apex	*Years Age at Apex Weight*	*Years Difference Apex Weight from Apex Height*
8	372	438	649	709	211	11.7	11.95§	−1.90
10	334	390	581	672	191	11.5	16.30‖	+1.95
18	366*	402	594	684	192	8.3	13.55¶	−.25
24	337	394	494	524	100	10.7	14.70	−.65
26	350†	356	600	640	244	10.2	13.70	+.55
30	350	392	605	649	213	12.8	15.70	0
32	374	406	597	692	191	15.2	15.60‖	+1.95
34	381	436	635	670	199	13.8	16.15	+.50
36	421	496	638	670	142	9.4	15.85	+.50
40	294	322	532	566	210	19.8	14.75	+.50
44	351	430	550	619	120	12.6	14.35	+1.00
50	386	446	608	633	162	12.2	15.35	+1.00
52	399	420	622	661	202	13.8	15.65	+.50
54	388	412	556	604	144	11.3	15.90	+1.00
58	380	396	538	603	142	9.6	17.35‖	+2.10
60	318	358	479	498	121	6.8	14.20	0
62	279	314	511	566	197	9.2	14.45	0
64	341	389	561	612	172	11.0	14.70	0
66	566	655	784	801	129	15.5	14.20	0
68	354	395	621	707	226	13.5	17.80‖	+2.45
72	339*	376	548	595	172	8.0	14.15	0
74	568‡	570	811	895	241	12.2	13.75	+1.50
78	349	374	552	611	178	11.0	16.40	+1.00
80	322	364	593	626	229	14.7	12.80	−1.05
82	343	411	644	673	233	12.5	13.30	−.60
84	329	388	580	644	192	11.0	14.45	−.95
86	390†	384	552	594	168	8.3	13.90	+.55
88	403	478	585	681	107	11.4	15.10‖	+2.55
92	283	323	445	505	122	7.6	15.05	+.95
96	339	378	525	577	147	9.8	14.05	+.50
100	286	326	516	603	190	10.4	12.95	0
104	453*	504	681	710	177	10.4	13.25	+.50
106	376	445	581	649	136	10.8	14.65	+.50
108	320	367	532	580	165	10.4	14.15	+1.10
110	356	414	567	658	153	12.6	13.55	−.45
112	378	430	570	645	140	10.6	13.15	0
116	319	348	540	622	192	10.8	14.25	+1.00
120	395	435	624	640	189	11.8	14.40	+.45
130	372	413	561		148	7.8	16.10	+.50
134	372	427	566	627	139	13.8	14.45	+.55
136	340	379	561	619	182	10.4	15.15	+.50

APPENDIX S—(*Concluded*)

MEASUREMENTS AND TIMING OF WEIGHT GROWTH—67 BOYS

Measurements in Tenths of Kilograms

Case Numbers	b − 3	Onset (b)	End (d)	d + 3	Gain b–d	Average Gain per .1 Year Weight Apex	*Years Age at Apex Weight*	*Years Difference Apex Weight from Apex Height*
144	373	411	615	698	204	11.4	14.75‖	+1.50
146	430	471	604	615	133	12.8	14.20	+1.50
150	405†	415	658	723	243	13.2	12.25	−.50
154	352	395	527	567	132	9.0	14.85	+1.95
164	359	400	551	579	151	10.4	12.95	−1.55
166	347	388	650	689	262	11.2	15.85	+2.00
168	385	417	657	700	240	10.7	13.30	−.50
176	362	405	536	594	131	7.7	14.90	+2.00
180	327	365	586	639	221	10.0	15.05	0
184	361	431	599	613	168	11.0	13.85	0
190	328	370	559	603	189	13.8	14.75	−.50
206	330	357	558	600	201	9.4	13.55	−.50
212	337	382	590	616‡	208	10.2	13.45	0
216	416*	476	704	743	228	17.8	11.25	−1.45
218	390	437	651	692‡	213	14.6	16.10	+.50
220	361	401	615	627‡	214	12.6	15.45	0
224	615	604	755	751	151	13.7	11.45§	−3.50
230	319	350	586	638	236	11.4	15.95	+2.60
234	375	449	743	777	294	16.2	15.15	0
236	530	536	614	676	78	11.4	11.85§	−2.55
242	330	355	522	585	167	11.4	15.05‖	+1.50
244	361	405	621	670	216	10.2	15.60	+.50
250	449*	489	621	641	141	9.2	13.45	+.50
292	399	458	643	707	185	11.2	14.15	+.50
294	370*	393	615	640	222	12.6	14.65	−.50
304	372*	411	567	616	156	8.6	13.65	−.50

* Taken at b − 1.
† Taken at b − 2.
‡ Taken at d + 2.
§ Preceding puberal period height.
‖ Following puberal period height.
¶ Two continuous peaks.

APPENDIX T

MUSCLE STRENGTH INDEX—67 BOYS

Case Number	*Index at Developmental Points* Kilograms				Gain	*Average Gain per .1 year Strength Apex*	*Age at Strength Apex*	*Difference Apex Strength from Apex Height*
	b − 3	b	d	d + 3	b–d	Kilograms	Years	Years
8	95.0	118.0	191.0	228.0	73.0	5.3	16.30	+2.45
10	82.5	109.5	166.0	214.5	56.5	8.3	16.30	+1.95
18	84.0*	101.5	150.5	218.0	49.0			
24	109.5	109.5	172.5	187.5	63.0	4.4	14.70	−.65
26	98.5†	106.5	203.5	224.0	97.0	6.4	18.15	+5.00
30	93.5	91.5	161.5	189.0	70.0	5.0	16.20	+.50
32	102.0	104.0	176.0	220.5	72.0	6.9	16.10	+2.45
34	102.0	110.0	186.0	214.5	76.0	9.1	16.15	+.50
36	104.0	118.0	179.0	209.0	61.0	6.2	14.35	−1.00
40	75.0	87.0	151.0	204.5	64.0	8.6	16.25	+2.00
44	100.5	114.0	161.0	199.5	47.0	3.4	13.85 16.90	+.50 +3.75
50	96.0	114.5	205.0	224.5	90.5	6.4	15.35	+1.00
52	82.5	107.5	185.0	233.0	77.5	5.5	14.15	−1.00
54	92.5	101.0	164.0	183.5	63.0	5.9	15.90	+1.00
58	81.0	72.0	135.0	164.0	63.0	7.3	16.35	+1.00
60	91.0	124.5	175.5	190.0	51.0	4.6	16.65	+2.45
62	83.0	112.0	205.0	244.0	93.0	6.3	16.00	+1.55
64	88.0	88.0	159.5	192.0	71.5	4.9	14.70	0
66	122.5	132.0	173.0	200.0	41.0	3.8	11.50 14.70	−2.70 +.50
68	96.5	116.0	178.0	216.0	62.0	5.0	16.30	+1.95
72	76.0*	83.5	123.0	148.0	39.5	4.2	15.65	+1.50
74	94.0†	110.0	206.0	233.0	96.0	8.1	13.75	+1.50
78	89.0	98.5	162.5	183.0	64.0	5.1	15.40	0
80	90.0	90.0	168.5	181.0	78.5	6.8	14.35	+.50
82	88.0	93.5	153.0	210.0	59.5	9.6	15.05	+1.15
84	85.5	96.5	182.0	210.0	85.5	5.5	14.45	−.95
86	67.0†	74.0	129.5	153.5	55.5	4.9	15.85	+2.50
88	89.0	97.0	142.5	200.0	45.5	8.1	15.65	+3.10
92	72.0	93.0	125.5	174.5	32.5	6.2	16.60	+2.50
96	93.0	111.0	165.0	179.5	54.0	4.3	14.05	+.50
100	68.0	80.5	134.0	184.0	53.5	6.4	12.95	0
104	98.0*	119.0	173.0	199.5	54.0	3.6	13.25	+.50
106	110.0	117.5	198.5	229.0	81.0	5.4	14.15	0
108	66.5	79.5	151.5	209.5	72.0	5.8	15.10	+2.05
110	100.5	106.5	173.5	223.0	67.0	5.6	14.50	+.50
112	89.0	97.5	142.5	190.0	45.0	5.0	15.80	+2.65
116	89.0	97.5	162.0	214.5	64.5	5.5	14.75	+1.50
120	92.0	98.0	167.0	203.0	69.0	5.0	15.45	+1.50
130	110.5	121.5	205.0		83.5	6.2	17.00	+1.40
134	96.5	109.5	163.0	225.0	53.5	7.1	16.55	+2.65
136	95.5	100.0	168.0	210.0	68.0	6.7	15.15	+.50

APPENDIX T—(*Concluded*)

MUSCLE STRENGTH INDEX—67 BOYS

Case Number	*Index at Developmental Points* Kilograms b − 3	b	d	d + 3	Gain b–d	*Average Gain per .1 year Strength Apex* Kilograms	*Age at Strength Apex* Years	*Difference Apex Strength from Apex Height* Years
144	82.0*	102.0	183.0	234.0	81.0	6.2	14.25	+1.00
146	78.0	89.5	136.5	188.5	47.0	4.6	13.15	+.45
150	104.0†	108.5	189.5	216.5	81.0	5.5	16.80	+4.05
154	86.5	114.0	154.5	198.5	40.5	7.0	11.45	−1.45
164	74.0	96.0	138.0	160.0	44.0	4.8	15.50	+1.00
166	89.0	103.0	209.5	242.0	106.5	4.0	15.85	+2.00
168	87.0	108.0	176.0	221.5	68.0	10.0	16.90	+3.05
176	112.5	115.0	165.5	174.5	50.5	5.8	12.40	−.50
180	87.0	94.0	185.5	214.0	91.5	5.0	17.50	+2.45
184	111.0	119.0	207.0	230.0	92.0	8.3	14.80	+.95
190	90.0	110.5	193.5	220.0	83.0	7.0	15.75	+.50
206	96.5	110.5	192.5	206.0	82.0	6.5	15.60	+1.55
212	87.0	97.0	190.5	223.0‡	93.5	5.7	15.05	+1.60
216	77.0*	103.0	181.0	218.0	78.0	8.4	13.70	+1.00
218	120.0	120.0	217.5	259.0	97.5‡	11.1	15.60	0
220	107.5	133.0	209.0	222.0	76.0‡	6.5	14.90	−.55
224	96.5	122.0	202.5	226.0	80.5	5.4	14.95	0
230	80.0	90.5	168.0	204.0	77.5	4.1	14.95	+1.60
234	98.5	116.5	223.5	251.0	107.0	6.9	15.15	0
236	120.0	132.0	172.0	179.0	40.0	6.1	15.40	+1.00
242	76.0	88.5	155.5	201.5	67.0	5.3	15.05	+1.50
244	76.5	91.5	163.0	176.0	71.5	5.2	16.15	+1.05
250	95.0*	101.5	155.5	186.0	54.0	4.3	15.95	+3.00
292	120.0	140.0	205.5	240.0	65.5	6.6	14.65	+1.00
294	101.0*	112.5	174.5	208.5	62.0	5.6	17.10	+1.95
304	100.0*	102.5	184.0	217.0	81.5	6.3	13.65	−.50

* b − 2 examination.
† b − 1 examination.
‡ d + 2 examination.

APPENDIX U-1

PUBIC HAIR RATINGS IN RELATION TO HEIGHT GROWTH

Case Number	Ratings at Developmental Points *b − 3*	*b*	*c*	*d*	*d + 3*	First Rating 2 in re b Years	First Rating 3 in re c Years	First Rating 4 in re c Years	First Rating 5 in re d Years	First Rating 6 in re d Years
8	1.00	2.00	4.25	5.00	5	−.25	−.63	−.23	−.30	1.80
10	1.00	1.00	3.50	5.00	5	−.65	−.30	+.20	−.65	1.65
18	2.00*	2.50	4.00	5.00	5		−1.68	+.02	−.30	1.80
24	1.50	2.50	4.00	5.00	6	−.20	−.78	−.18	−.20	.65
26	1.00†	1.00	3.73	5.00	5	+.65	−.25	+.10	−1.15	2.75
30	1.00	1.00	2.50	5.00	6	+1.15	+.25	+.65	0	.25
32	1.00	2.00	3.50	4.50	5	−.25	−.20	+.30	+.25	1.65
34	1.00	1.50	2.50	4.75	6	−.12	+.12	+.37	+.25	1.45
36	1.00	1.00	3.00	5.50	6	+.75	+.02	+.52	−.25	.20
40	1.00	2.00	3.50	4.50	5	−.25	−.50	+.50	+.25	1.75
44	2.00	2.50	5.00	5.00	5		−1.00	−.25	−1.25	2.25
50	2.00	2.00	3.00	4.50	6	−1.25	0	+1.00	+.25	.75
52	1.00	1.00	4.00	5.00	6	+.75	−.25	0	−.25	.75
54	3.00	3.00	4.25	5.00	6		−.28	−.30	−.80	1.20
58	0	1.00	3.20	5.00	6	+.75	−.05	+.20	−.25	1.25
60	1.00	2.00	5.00	5.00	5	−.30	−.48	−.18	−1.15	2.75
62	1.00	1.00	3.50	5.00	5	+.80	−.09	+.07	−1.30	1.70
64	2.00	2.50	4.00	5.00	6	−.30	−1.23	+.02	−1.25	1.25
66	1.00	1.50	3.00	4.00	5	+.35	−.23	+.97	+.30	1.90
68	1.50	3.25	4.00	5.00	6	−1.15	−2.48	−.98	−.80	.80
72	0*	1.00	1.50	4.00	5	+1.20	+.47	+.77	+1.25	2.85
74	1.00†	1.00	3.00	5.00	5	+.70	−.45	+.45	−.20	2.20
78	1.00	1.50	4.50	5.00	6	+.25	−.48	−.18	−1.30	1.30
80	2.00	2.25	4.00	5.00	5		−.55	+.05	−.70	2.30
82	1.00	1.00	2.65	5.00	5	+1.30	+.15	+.75	−.30	1.70
84	2.00	3.00	4.33	5.00	6	−1.25	−2.00	−.50	−.75	.75
86	1.00†	2.50	4.20	5.00	5		−1.20	−.05	−1.30	3.30
88	1.00	1.00	3.00	4.00	5	+.75	0	+1.30	+.85	1.75
92	1.00	2.25	3.60	5.00	6	−.80	−.30	+.20	−.80	1.20
96	3.00	3.00	4.00	5.00	5		−2.50	0	−.75	2.25
100	2.00	2.50	4.00	5.00	5		−1.00	−.50	−.80	1.70
104	1.00*	2.00	3.50	5.00	5	−.25	−.25	+.25	−.75	2.85
106	1.00	1.50	3.40	5.00	5	+.30	−.20	+.30	−.30	2.30
108	1.00	1.00	3.00	5.00	5	+.75	−.03	+.57	−.20	1.80
110	1.50	2.50	3.40	5.00	5	−.75	−.68	+.52	−.30	1.80
112	1.00	1.50	4.00	4.25	5	+.25	−.58	−.23	+.80	1.80
116	1.00	1.00	4.00	5.00	5	+.75	−.25	0	−.25	1.75
120	1.00	1.75	2.40	5.00	5	+.25	+.23	+.57	−.30	1.70
130	2.00	2.25	4.45	6.00	–	−2.35	−.78	−.18	−1.20	−.70
134	1.00	1.25	3.40	4.75	6	+.45	−.23	+.25	+.30	.80
136	2.00	2.50	3.60	5.00	6		−1.18	+.22	−.30	.70
144	1.00*	1.00	1.73	4.25	5	+1.70	+.42	+.67	+.75	2.25
146	1.00	1.00	2.90	5.00	5	+.70	+.02	+.36	−.30	2.70
150	1.00†	1.00	4.16	5.00	5	+1.15	−.35	−.10	−1.25	2.15
154	1.00	2.00	3.80	5.00	5	−.75	−.40	+.10	−.65	1.85
164	1.00	2.00	4.00	5.00	6	−.55	−.53	−.03	−.20	1.20
166	1.00	1.00	1.40	5.00	6	+1.96	+.55	+1.05	0	.20
168	1.00	1.50	4.50	5.00	6	+.25	−1.05	−.20	−1.25	1.25
176	1.00	2.00	3.00	4.00	5	−.30	−.05	+.55	+1.30	1.70
180	1.00	1.00	2.00	5.00	6	+1.20	+.52	+.77	0	.25
184	1.00	1.00	2.60	4.50	6	+1.30	+.14	+.82	+.25	.75

APPENDIX U–1—(*Concluded*)

PUBIC HAIR RATINGS IN RELATION TO HEIGHT GROWTH

Case Number	Ratings at Developmental Points: b − 3	b	c	d	d + 3	First Rating 2 in re b Years	First Rating 3 in re c Years	First Rating 4 in re c Years	First Rating 5 in re d Years	First Rating 6 in re d Years
190	1.00	2.00	4.00	5.00	6	−.80	−.53	−.03	−.85	1.25
206	1.00	1.00	3.20	4.50	6	+1.25	−.05	+.20	+.25	.75
212	1.00	1.00	2.66	4.75‡	6	+1.20	+.17	+1.02	+.25	.65
216	1.00*	1.00	4.00	5.00	6	+.75	−.73	−.48	−1.30	2.20
218	1.50	2.00	4.65	6.00‡	6	−.75	−.78	−.26	−1.20	−.30
220	1.00	1.00	3.40	6.00‡	6	+1.00	−.18	+.32	−.50	−.30
224	2.00	2.50	5.00	6.00	6	−1.25	−1.08	−.58	−1.30	−.30
230	1.00	2.00	4.00	5.00	6	−.25	−1.05	+.05	−1.25	.65
234	1.00	2.50	4.00	5.00	6	−.30	−1.23	−.23	−.25	.65
236	3.00	3.00	3.50	5.00	6		−2.23	+.27	−.30	.70
242	2.00	2.00	3.00	4.50	5		−.53	+.57	+.25	2.25
244	1.00	1.00	3.00	5.00	6	+.90	−.05	+.95	−.25	.65
250	1.00*	1.00	3.60	5.00	6	+.35	−.30	+.20	−.75	2.15
292	2.00	2.50	4.40	5.00	5		−.78	−.28	−.30	1.80
294	1.00*	1.50	3.98	5.00	6	+.30	−.66	+.02	−.75	1.25
304	1.00*	1.50	3.50	4.75	5.00	+.30	−.23	+.27	+.25	2.15

* b − 2 examination.
† b − 1 examination.
‡ d + 2 examination.

APPENDIX U-2

PUBIC HAIR RATINGS IN RELATION TO TESTES AND GLANS PENIS GROWTH

Case Number	T_1	P_1	P_2	T_2
8	1	2	5	5
10	1	1	5	5
18	2	3	4	5
24	1	1.5	4	5
26		1	5	5
30	1	1	4	6
32	1	2	4	5
34	1	2	4.5	5
36	1	1	4	6
40	1	2	4	5
44	2	3	5	5
50	2	2	4	6
52	1	1	4	6
54	3	3	5	5
58		2	5	5
60	1	2	5	5
62	1	1	5	5
64	2	2	5	6
66	1	1	3	5
68	1.5	3	5	6
72		1	4	4
74		1	5	5
78	1	2	5	6
80	2	2.5	5	5
82	1	1	5	5
84	1.5	3	5	6
86		3	5	5
88	1	1	3	5
92	1	2	5	5
96	3	3	5	5
100	2	2	5	5
104		2	5	5
106		1	4	5
108	1	1	4	5
110		2	5	5
112	1	1	4.5	5
116	1	1	5	5
120	1	2	5	5
130	2	2	5	
134	1	1	4	6
136	2	2	5	6
144	1	1	4	5
146		1	5	5
150		1	5	5
154	2	2	5	5

APPENDIX U–2—(*Concluded*)

PUBIC HAIR RATINGS IN RELATION TO TESTES AND GLANS PENIS GROWTH

Case Number	T_1	P_1	P_2	T_2
164	1	2	5	6
166	1	1	4	6
168	1	2	5	6
176	1	2	4	4.5
180	1	1.5	4	6
184	1	1	3.5	5
190	1	2	5	6
206	1	1	4	5
212	1	1	3.5	5
216	1	1	5	5
218	2	2	5	6
220	1	1	4	6
224	1	2	5	6
230	1	2	5	6
234	1	1	4	6
236	2	3	4	5
242	2	2	5	5
244	1	1	4	6
250	1	2	5	5
292		2	5	5
294		1	4	5
304		1	5	5

APPENDIX V–1

TECHNIQUE USED IN DETERMINING THE ONSET AND END OF THE PUBERAL GROWTH OF GLANS PENIS

In making the determinations of the onset and end of the puberal period of accelerated growth of glans penis, as published in this study, the photographic series for each boy was used. The photographs were mounted in serial order with a minimum of space between each two prints so that comparison could be readily made. The instructions for making the determinations were as follows:

1. Note the part of the series in which there is obvious change in size of penis from picture to picture.
2. Focus attention upon the diameter of the penis at the base of the glans; do not base your determination of relative size upon either the length or thickness of the shaft.
3. From the period of marked growth follow the pictures back through the younger ages to the one which appears to divide a period of very little change or no change from the puberal period of increase in size at each succeeding picture.
4. Repeat this process twice.
5. Record the age at the photograph chosen as the age at onset of the puberal growth period of glans penis (P_1).
6. In determining the end of the period (P_2), start where increase is obvious and follow through the later photographs. Select the photograph which appears to separate the puberal period of rapid increase from the later adolescent period of little or no increase. The chronological age at the time this photograph was taken will be recorded as the C.A. at P_2. Repeat this process twice.

The ratings were made by three persons independently. When there was disagreement the final rating was decided by conference.

APPENDIX V–2

TIMING OF GROWTH OF GLANS PENIS AND TESTES—67 BOYS

Case Number	*Chronological Age in Years* P_1	P_2	T_1	T_2
8	12.6	15.0	11.8	16.0
10	13.2	15.1	11.7	17.1
18	12.5	14.7	11.6	16.2
24	13.4	15.5	12.4	16.4
26	11.8	13.9	Before 11.1	15.5
30	14.0	15.9	12.9	18.1
32	11.8	14.4	11.4	15.8
34	14.4	15.9	12.9	16.9
36	13.6	16.1	12.6	17.6
40	13.0	15.0	12.0	16.0
44	12.6	14.6	11.8	16.7
50	13.6	16.1	12.6	17.1
52	13.9	15.9	12.9	17.4
54	13.2	15.1	12.1	16.7
58	14.0	16.1	12.5	17.1
60	12.3	14.9	11.9	16.4
62	13.2	15.2	12.6	16.7
64	12.4	14.9	11.9	17.0
66	13.3	15.3	12.2	17.0
68	13.1	16.0	12.0	17.6
72	11.9	14.9	11.3	15.9
74	11.0	14.0	Before 10.4	15.4
78	14.1	16.6	13.2	18.2
80	12.6	14.1	11.6	15.6
82	12.0	14.2	9.9	15.3
84	13.7	15.7	12.1	17.2
86	12.2	14.2	Before 11.6	15.6
88	11.8	13.8	11.3	15.9
92	13.3	15.9	12.3	16.9
96	12.3	14.3	11.3	16.3
100	11.6	14.7	11.1	15.8
104	11.5	13.5	Before 11.5	15.5
106	12.8	14.9	11.9	16.4
108	11.3	13.9	10.8	15.4
110	11.7	14.2	10.2	14.8
112	12.4	15.1	10.8	15.6
116	12.5	14.5	11.5	15.5
120	12.6	14.6	11.6	15.7
130	14.4	16.3	12.7	After 17.2
134	12.7	14.7	12.1	16.3

APPENDIX V–2—(*Concluded*)

TIMING OF GROWTH OF GLANS PENIS AND TESTES—67 BOYS

Case Number	Chronological Age in Years			
	P_1	P_2	T_1	T_2
136	12.3	15.4	11.3	16.9
144	11.5	14.0	10.4	16.1
146	11.9	14.6	Before 10.9	14.9
150	11.7	14.6	Before 11.0	16.1
154	12.1	14.6	11.6	15.7
164	12.2	15.3	10.6	16.7
166	13.1	15.6	12.0	16.5
168	12.5	15.1	11.0	17.1
176	12.7	15.2	11.6	15.7
180	13.2	15.8	12.2	16.8
184	11.6	14.1	11.6	15.5
190	13.9	16.0	12.9	18.1
206	12.8	15.3	11.8	16.4
212	12.2	14.8	11.2	15.8
216	11.0	13.5	9.9	15.0
218	14.2	16.4	13.2	17.3
220	13.7	16.2	13.1	17.6
224	13.1	15.2	11.6	16.3
230	12.1	15.2	11.2	17.1
234	12.3	15.4	11.8	16.8
236	12.7	15.2	12.1	16.2
242	12.2	14.8	10.7	15.3
244	13.5	15.9	13.0	17.3
250	12.2	13.7	10.8	14.7
292	12.9	14.9	Before 11.9	16.5
294	12.3	15.4	Before 12.3	16.9
304	12.8	15.4	Before 12.3	15.9

APPENDIX W–1

TIMING OF POINTS IN PHASE PATTERN—CHRONOLOGICAL AGE FOR 67 CASES

Case Number	*Stem Length*				*Leg Length*				*Biacromial Width*				*Bi-iliac Width*			
	1	3	5	7	1	3	5	7	1	3	5	7	1	3	5	7
8	11.45	12.85	15.80	17.30		12.35	15.30	16.30	11.45	12.35	16.00	17.70	11.45	12.35	15.30	16.85
10	12.05	13.85	15.85	16.80		12.95	15.35	16.35	12.05	13.40	16.30	17.30	12.05	13.40	15.85	17.30
18	11.20	12.75	15.95	17.45		11.75	14.90	16.95		12.75	15.95	16.95	11.20	12.75	15.95	16.95
24	12.15	13.70	16.60		11.25	13.15	16.15	17.50	12.65	13.70	16.60		11.25	12.65	15.70	17.05
26		11.95	15.75	16.65		11.45	14.65	15.75		11.45	14.65	16.70		11.45	14.65	15.75
30	12.70	13.75	17.25		11.20	13.20	16.75	17.75	?	13.75	16.75	17.80	11.70	13.75	16.75	
32		12.05	15.60	17.70		11.60	15.15	16.10	?	11.60	15.15	?	11.60	13.10	16.10	17.70
34	12.15	14.15	17.15		11.70	14.15	16.15	17.15	11.70	14.15	16.90		12.15	13.65	16.65	17.75
36	12.30	13.85	16.80	17.80	11.80	13.35	16.35	17.30	12.30	13.85	15.85	17.80	12.85	13.85	16.35	17.30
40	11.80	12.75	15.25	16.75	11.25	12.75	14.75	16.25	11.25	13.25	15.75	17.25	11.80	?	16.00	17.50
44	11.45	12.35	15.40	16.90		12.35	14.85	16.20		12.10	15.40	16.90	11.95	12.85	14.85	16.90
50	12.30	13.85	16.35	17.85	11.80	13.85	16.85		12.30	14.35	17.35		12.30	14.35	16.85	17.85
52	12.10	14.15	17.15	18.15	11.60	14.15	16.15	17.65	12.10	13.15	17.65		13.15	14.65	16.65	17.65
54	11.85	13.45	17.35		11.35	12.90	16.40	17.35	12.35	14.40	16.90	18.10	11.85	13.45	16.10	17.35
58	12.30	13.75	16.35	17.85		13.25	16.35	17.85	12.30	14.25	15.80	18.30	12.75	14.25	16.35	17.85
60		12.60	15.65	18.15		11.60	15.15	16.15	11.60	13.70	15.65	18.15	11.60	12.60	15.65	17.15
62	12.40	13.95	16.00	17.50	11.85	13.45	15.45	16.50		12.50	16.00	17.50		12.90	14.95	16.50
64	11.70	12.70	15.75	17.25		11.70	15.75	17.75	11.20	12.70	15.75	17.75	11.20	13.25	15.20	17.25
66	12.20	13.65	15.60	17.75	11.50	13.05	16.60		11.50	13.65	15.60	17.75	11.50	13.65	16.15	17.75
68	11.85	13.35	17.30	18.60	11.35	12.30	16.30	17.80	11.35	13.85	17.80		12.30	13.35	17.30	
72		12.10	16.15	17.25		13.60	16.15	?		13.60	15.65			12.55	15.65	17.25
74		10.70	15.60	17.30		10.70	14.40	15.70		10.70	14.20	17.30		10.70	14.70	16.20
78	13.40	14.35	16.90	18.45	12.90	13.85	16.90	18.45	12.90	13.85	16.90		13.40	14.35	16.40	18.45
80	11.30	12.30	14.80	16.90		11.80	14.35	15.85	11.30	12.30	14.80	16.90	11.30	12.30	14.80	16.90
82	10.25	11.50	15.05	16.50	10.25	11.20	14.50	16.50	10.60	12.50	15.05	16.50	10.75	13.30	14.50	16.05
84	12.40	14.45	16.45	18.80	11.40	13.95	15.95	17.20	12.95	14.45	17.20		13.45	14.90	16.95	18.00
86		12.20	14.90	17.40		11.90	14.40	16.35		12.85	16.35	17.40		11.90	15.40	17.40
88	10.90	12.05	14.55	16.10		11.10	14.05	15.55	11.10	13.05	15.10	16.55		11.30	14.55	16.10
92	12.10	13.15	15.60	16.60	11.60	12.55	16.10	17.10		12.55	15.60	17.60	12.10	13.05	15.60	18.15
96	11.60	13.05	16.05	17.60		12.55	15.55	17.15	11.60	13.05	15.05	17.10		12.10	15.55	17.10
100	10.80	11.85	15.00	17.40		11.35	14.45	17.40	10.80	12.10	15.00	17.40	10.80	12.10	15.00	16.50
104	11.20	12.25	14.75	16.85		11.75	14.25	15.85		11.20	14.25	15.80		12.25	14.25	17.35
106	12.10	13.60	16.70	18.10		12.55	15.60	17.45	12.10	14.65	16.70	18.50	12.55	13.90	15.60	16.70
108	11.15	12.05	15.10	17.15	10.50	12.05	14.60	16.20	11.15	12.55	15.10	17.15	11.15	12.05	15.10	17.15
110	11.00	12.50	14.50	16.05	10.50	11.95	15.05	16.50	10.50	11.45	14.00		10.80	12.50	15.05	
112	11.15	12.15	16.30	17.25		11.70	14.80	16.30	11.15	12.15	15.80	17.75	11.15	12.65	15.35	17.25
116	10.75	12.25	?	16.30	11.75	12.75	14.75	16.30	11.25	13.25	15.25	17.20	11.25	12.25	15.25	16.30
120	11.85	12.90	14.90	17.45	11.40	12.35	14.40	15.95	10.90	12.90	15.45	17.45	11.40	12.35	14.90	17.45
130	12.05	13.65	17.00		11.10	13.05	16.55	17.80	11.10	13.65	16.10		11.10	14.65	17.00	
134	12.40	13.35	16.05		11.30	13.35	15.50	16.55	10.30	12.40	16.55		10.80	12.40	14.95	16.55
136	11.55	13.00	15.70		10.60	12.05	16.20	17.80	11.15	12.05	16.20	17.10	11.15	12.05	15.15	17.10
144	10.75	12.20	15.00	16.30		11.75	14.25	15.25	10.75	12.20	15.25	16.75	11.30	12.20	15.25	16.30
146	11.20	12.20	15.75	16.70		11.70	?	15.75	11.20	13.15	15.20	16.25	11.20	13.15	15.75	16.70
150		11.35	15.35	16.35			14.85	16.35		12.25	14.85	17.25		11.35	15.35	16.35
154	11.45	12.35	15.95	17.85		11.45	14.85	15.95	10.95	11.85	15.40		10.95	12.35	15.95	17.40
164	11.55	12.45	16.00	17.40	11.00	11.95	15.50	16.50	11.95	13.45	16.00		11.00	13.45	15.50	16.50
166	11.35	12.75	?	17.30	11.35	12.75	15.35	16.30	11.35	12.25	16.30		11.75	12.75	16.30	17.30
168	11.85	12.75	15.35	16.40	11.35	12.25	14.35	15.85	11.35	12.25	14.85	17.35	11.35	12.25	15.35	16.90
176	11.85	12.90	14.90	16.40	12.40	13.35	15.95	17.85		11.85	15.95	17.40	10.90	12.40	14.40	16.40
180	11.95	13.00	16.55	18.20	?	12.50	16.05	17.05	11.00	13.45	16.55		11.50	14.00	16.55	17.50
184	11.35	12.30	15.25	16.70	10.95	11.80	14.35	15.75	11.35	12.85	15.75		10.45	12.30	14.35	16.25
190	12.20	14.20	17.45		12.65	14.75	16.75	?	12.20	14.20	16.85		12.65	14.20	16.85	
206	11.55	12.55	16.15	17.50	11.10	12.05	15.60	16.65	11.10	14.05	16.65		11.10	14.55	16.40	
212	10.50	12.50	15.55			11.45	14.50	15.55	10.80	13.00	15.55		11.00	11.95	15.05	16.45
216		10.75	14.75	16.20		10.75	13.70	16.20		10.75	14.20	16.20		10.75	13.70	15.75
218	12.90	13.95	17.00		12.35	13.95	17.00		10.95	13.95	16.55		11.45	13.95	17.00	
220	11.85	13.90	16.90		11.85	13.90	15.95	17.40	11.85	14.35	16.40		12.85	13.90	16.90	
224	12.85	13.85	16.00	17.40	10.95	13.35	16.45	18.00	10.95	13.85	16.00	17.40	11.85	13.85	16.00	
230	10.90	12.35	16.85	18.00		11.85	15.95	17.30		11.40	15.20	16.85		11.85	15.45	17.30

APPENDIX W–1—(*Concluded*)

TIMING OF POINTS IN PHASE PATTERN—CHRONOLOGICAL AGE FOR 67 CASES

Case Number	*Stem Length*				*Leg Length*				*Biacromial Width*				*Bi-iliac Width*			
	1	3	5	7	1	3	5	7	1	3	5	7	1	3	5	7
234	12.05	13.10	15.65	16.60		12.55	14.65	16.60	11.10	13.10	16.60	17.55	11.60	13.65	16.60	17.55
236	12.95	13.95	15.90	17.75	11.85	13.45	15.90	17.30	10.90	12.95	15.90	17.75	11.40	13.45	16.40	17.30
242	10.95	11.90	15.55	17.50		11.40	14.55	16.05		11.90	15.55		10.95	11.90	15.05	17.05
244	12.75	14.20	16.15	17.60		12.75	15.60	16.65		13.25	16.15		11.80	13.00	16.15	17.10
250	11.05	12.45	15.45	17.40		11.55	14.95	15.95		11.30	14.95		11.05	12.00	14.95	16.40
292	12.15	13.15	15.20	17.70		12.65	15.75	17.25		12.65	15.20	17.25		12.65	15.75	17.25
294		13.10	16.65	17.60		13.10	15.65	16.65		13.10	16.65	17.60	12.55	14.15	15.65	16.65
304		12.55	15.15	17.10			14.65	16.10		12.55	16.60			13.65	15.65	
Total cases	57	67	64	66	33	65	65	63	46	67	67	41	54	66	67	57

APPENDIX W–2

PHASE DURATION IN YEARS

Case Numbers	*Stem Length*			*Leg Length*			*Biacromial Width*			*Bi-iliac Width*			*Sum of Duration Phases I, II, III*			
	I	II	III	I	II	III	I	II	III	I	II	III	S.L.	L.L.	Bi-ac.	Bi-il.
8	1.40	2.95	1.50		2.95	1.00	.90	3.65	1.70	.90	2.95	1.55	5.85		6.25	5.40
10	1.80	2.00	.95		2.40	1.00	1.35	2.90	1.00	1.35	2.45	1.45	4.75		5.25	5.25
18	1.55	3.20	1.50		3.65	2.05		3.00	1.20	1.55	3.00	1.20	5.25			5.75
24	1.55	2.90		.90	3.00	1.35	1.05	2.90		1.40	3.05	1.35		6.25		5.80
26		3.80	.90		3.20	1.10		3.20	2.05		3.20	1.10				
30	1.05	3.50		2.00	3.55	1.00		3.00	1.05	2.05	3.00			6.55		
32		3.55	2.10		3.55	.95		3.55		1.50	3.00	1.60				6.10
34	2.00	3.00		2.45	2.00	1.00	2.45	2.75		1.50	3.00	1.10		5.45		5.60
36	1.55	2.95	1.00	1.55	3.00	.95	1.55	2.00	1.95	1.00	2.50	.95	5.50	5.50	5.50	4.45
40	.95	2.50	1.50	1.50	2.00	1.50	2.00	2.50	1.50			1.00	4.95	5.00	6.00	3.95
44	.90	3.05	1.50		2.50	1.35		3.05	1.50	.90	2.00	2.05	5.45			4.95
50	1.55	2.50	1.50	2.05	3.00		2.05	3.00		2.05	2.50	1.00	5.55			5.55
52	2.05	3.00	1.00	2.55	2.00	1.50	1.05	4.50		1.50	2.00	1.00	6.05	6.05		4.50
54	1.60			1.55			1.55	3.00	1.20	1.60	2.65	1.25	5.05	5.05	5.75	5.50
58	1.45	2.60	1.50		3.10	1.50	1.95	1.85	2.20	1.50	1.85	1.75	5.55		6.00	5.10
60		3.05	2.50		3.75	1.00	2.10	1.95	2.00	1.00	3.05	1.50			6.05	5.55
62	1.55	2.05	1.50	1.60	2.00	1.05		3.50	1.50		2.05	1.55	5.10	4.65		
64	1.00	3.05	1.50		4.05	2.00	1.50	3.05	2.00	1.05	1.95	2.05	5.55		6.55	6.05
66	1.45	1.95	2.15	1.55	3.10		2.15	1.95	2.15	2.15	1.95	2.15	5.55		6.25	6.25
68	1.50	3.95	1.30	.95	4.00	1.50	2.50	3.95		1.05	3.95		6.75	6.45		
72		4.05	1.10		1.55			2.05			3.10	1.60				
74		4.90	1.70		3.50	1.50		3.50	3.10		3.00	1.50				
78	.95	2.55	1.55	.95	3.05	1.55	.95	3.05		.95	2.05	2.05	5.05	5.55		5.05
80	1.00	2.50	2.10		2.55	1.50	1.00	2.50	2.10	1.00	2.50	2.10	5.60		5.60	5.60
82	1.25	3.55	1.45	.95	3.30	2.00	2.25	2.55	1.45	2.55	1.20	1.55	6.25	6.25	6.25	5.30
84	2.05	2.00	2.35	2.55	2.00	1.00	1.50	2.50		1.45	2.05	1.05	6.40	5.55		4.55
86		2.70	2.50		2.50	1.95		2.55	2.00		2.50	1.95				
88	1.15	2.50	1.55		2.95	1.50	1.95	2.05	1.45		3.25	1.55	5.20		5.45	
92	1.05	2.45	1.00	.95	3.55	1.00		3.05	2.00	.95	2.55	1.50	4.50	5.50		5.00
96	1.45	3.00	1.55		3.00	1.05	1.45	2.00	2.05		3.45	1.55	5.50		5.50	
100	1.05	3.15	2.40		3.10	2.95	1.30	2.90	2.40	1.30	2.90	2.10	6.60		6.40	6.30
104	1.05	2.50	2.10		2.50	1.60		3.05	3.10		2.00	1.60	5.65			
106	1.50	3.10	1.40		3.05	1.10	2.55	2.05	1.80	1.35	1.70	1.10	6.00		6.40	4.15
108	.90	3.05	2.05	1.55	2.55	1.60	1.50	2.45	2.05	.90	3.05	2.05	6.00	5.70	6.00	6.00
110	1.50	2.00	1.55	1.45	2.55	1.70	.95	2.55		1.50	2.55		5.05	5.70		
112	1.00	4.15	.95		3.10	1.50	1.00	3.65	1.95	1.50	2.70	1.80	6.10		6.60	6.10
116	1.50			1.00	2.00	1.55	2.00	2.00	1.95	1.50	2.50	1.05	5.55	4.55	5.95	5.05
120	1.05	2.00	2.55	.95	2.05	1.55	2.00	2.55	2.00	.95	2.55	2.55	4.55	4.55	6.55	6.05
130	1.60	3.35		1.95	3.50	1.25	2.55	3.35		3.55	2.35			6.70		
134	.95	2.70		2.05	2.15	1.05	2.10	4.15		1.60	2.55	1.60		5.25		5.75
136	1.45	2.70		1.45	4.15	1.35	.90	4.15	.90	.90	3.10	1.95		6.95	5.95	5.95
144	1.45	2.80	1.30		2.50	1.00	1.45	3.05	1.50	.90	3.05	1.05	5.55		6.00	5.00
146	1.00	3.55	.95				1.95	2.05	1.05	1.95	2.60	.95	5.50		5.05	4.50
150		4.00	1.00			1.00		2.60	2.40		4.00	1.00				
154	.90	3.60	1.90		3.40	1.10	.90	3.55		1.40	3.60	1.45	6.40			6.45
164	.90	3.55	1.40	.95	3.55	1.00	1.50	2.55		2.45	2.05	1.00	5.85	5.50		5.50
166	1.40			1.40	2.60	.95	.90	4.05		1.00	3.55	1.00	5.95	4.95		5.55
168	.90	2.60	1.05	2.00	2.10	1.50	.90	2.60	1.50	.90	3.10	1.55	4.65	4.50	6.00	5.55
176	1.05	2.00	1.50	.95	2.60	1.90		4.10	1.45	1.50	2.00	2.00	4.65	5.45		5.50
180	1.05	3.55	1.65		3.55	1.00	2.45	3.10		2.50	2.55	.95	6.25			6.00
184	.95	2.95	1.45	.85	2.55	1.40	.80	2.90		1.85	2.05	1.90	5.35	4.80		5.80
190	2.00	3.25		2.10	2.00		2.00	2.65		1.55	2.65					
206	1.00	3.60	1.35	.95	3.55	1.05	2.95	2.60		3.45	1.85		5.95	5.55		
212	2.00	3.05			3.05	1.05	2.00	2.55		.95						5.45
216		4.00	1.45		2.95	2.70		3.45	2.00		2.95	2.05				
218	1.05	3.05		1.60	3.05		3.00	2.60		2.50	3.05					
220	2.05	3.00		2.05	2.05	1.45	2.50	2.05		1.05	3.00			5.55		
224	1.00	2.15	1.40	2.40	3.10	1.55	2.90	2.15	1.40	2.00	2.15		4.55	7.05	6.45	
230	1.45	4.50	1.15		4.10	1.35		3.80			3.80	1.85	7.10			

APPENDIX W–2— (*Concluded*)

PHASE DURATION IN YEARS

Case Numbers	*Stem Length* I	II	III	*Leg Length* I	II	III	*Biacromial Width* I	II	III	*Bi-iliac Width* I	II	III	*Sum of Duration Phases I, II, III* S.L.	L.L.	Bi-ac.	Bi-il.
234	1.05	2.55	.95		2.10	1.95	2.00	3.50	.95	2.05	2.95	.95	4.55		6.45	6.15
236	1.00	1.95	1.85	1.60	2.45	1.40	2.05	2.95	1.85	2.05	2.95	.90	4.80	5.45	6.85	5.90
242	.95	3.65	1.95		3.15	1.50		3.65		.95	3.15	2.00	6.55			6.10
244		1.95	1.45		2.85	1.05		2.90		1.20	3.15	.95				5.30
250	1.40	3.00	1.95		3.40	1.00		3.40		.95	2.95	1.45	6.35			5.45
292	1.00	2.05	2.50		3.10	1.50		2.55	2.05		3.10	1.50	5.55			
294		3.55	.95		2.55	1.00		3.55	.95	1.60	1.50	1.00				4.10
304		2.60	1.95			1.45		4.05			2.00					
Total cases	56	64	54	33	63	60	46	67	40	53	65	56	46	29	26	45

APPENDIX X

CRITICAL RATIOS

The significance of the difference between measurements at the four successive developmental points was obtained by computing a critical ratio of the differences in measurement between each two consecutive developmental points.

The computation was made as follows: the standard deviation of the differences in the measurements was divided by the square root of the number of cases (67) to give the standard error of the differences. $\sigma_{D_M} = \frac{\sigma_{\text{Diff}}}{\sqrt{N}}$ The critical ratio was computed by dividing the mean differences by the standard error of the differences $CR = \frac{D_M}{\sigma_{D_M}}$.

All critical ratios except those noted in the text were over 3.00, a stringent criterion for significance which indicates that a difference as large as the one obtained between the measurements at these developmental points would occur by chance less than one time in a thousand.

INDEX

NOTE: **Bold face** numbers indicate illustrations; the letter *f* preceding a number indicates reference to a footnote.

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